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THE TREATMENT OF CARCINOMA OF THE RECTUM BY IRRADIATION[1]

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IT IS generally accepted that almost all malignant neoplastic diseases of the rectum are amenable to treatment by radium and roentgen ray. Most of the tumors are of the adenocarcinomatous type, and the degrees of malignancy vary. Among the remainder are colloid carcinoma, squamous-cell carcinoma, sarcoma, benign tumor (polyp) undergoing malignant degeneration, and so forth. If similar tumors are in suitable situation anatomically, for thorough irradiation, they respond favorably and thus a valuable therapeutic guide is furnished.

The foregoing observation has aided materially in selecting patients for treatment as well as in anticipating the results. From the standpoint of the radiotherapist, these malignant neoplastic tumors of the rectum do respond to treatment, but it is clinically impossible to state, at the time the patient is accepted for treatment, the degree of response that can be expected in a given case. This feature is not a problem peculiar to lesions of the rectum; it is, instead, a common factor occurring in the management of malignant neoplastic disease in general. The individual patient seems to have a characteristic mechanism, which acts to bring about constructive repair in the neoplastic lesion. Thus far this mechanism has defied analysis. It is impossible to select, before treatment, the case in which decided and prompt restoration of the part will occur. The general condition of the patient is a factor in a satisfactory response. And yet patients whose general condition was poor have responded to the initial treatment with equal promptness.

The grade of malignancy of the tumor may influence the response to treatment. However, tumors graded 1 have responded as well as those graded 3 or 4. Few of the rectal tumors are graded 1; usually they are graded 2 or 3. There is evidence to show that tumors graded 1 or 2 remain small and local for a long time. With this in mind, the procedure should be arranged to meet the requirements. Surgical treatment is preferred for tumors graded 1 or 2, while those graded 3 or 4 should receive preoperative irradiation except in instances in which preliminary surgical procedures are indicated. Among such operations colostomy is the most common; in a few cases the coccyx has been removed and the anal sphincter sacrificed in order to facilitate the application of radium.

The type or grade of malignancy is important in deciding on the most effective

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treatment in a given case. To-day a microscopic study of specimens removed is the most reliable index. Complete proctoscopic examinations are also essential as a preliminary to the choice of the most effective procedures. Surgery, radium, roentgen rays and surgical diathermy are at our disposal. The application of any one or a combination of these requires painstaking effort. Refinements in the technic of these methods, as well as the consideration of clinical and laboratory data, clearly indicate the importance of co-operation and the fact that only through such activities can the results of the past be improved on.

As yet, it is impossible to classify or group cases, since operability is determined by the skill of the surgeon and the physical status of the patient. A satisfactory classification must depend on the situation of the lesion, the extent of tissue involvement, and the grade of the malignancy. From the standpoint of the radiotherapist these considerations furnish the best classification for irradiation. The adequate or inadequate application of radium depends on the site of the tumor. The amount of element and filtration, as well as the time of application, is largely governed by the size and situation of the mass.

Many more cases must be observed before definite information can be available with regard to what constitutes the most effective irradiation. My experience centers chiefly around the massive, inoperable cases. Many valuable data were obtained in the management of these cases. They were classified as inoperable on many counts, such as massive local growth, growth infiltrating bladder or prostatic tissue, and multiple local or distant metastatic tumors, for example, in the perirectal lymph nodes, liver, and so forth. In a few cases the general condition of the patient would not permit radical surgical procedures. Palliation may be hoped for in this group by cautious irradiation. The broken-dose technic seems to meet the individual needs of the patient. The more treatment is individualized, the more enduring will be the results. The broken-dose method with a few days between applications, finished within two or three weeks, affords the most effective treatment.

Colostomy, or the chance of losing control of the anal sphincter, was the greatest dread of the patients whose cases are reported here. The treatment was designed to avoid adding a greater risk to the operation, should it prove necessary later. In one instance the lesion was operable; however, the patient's general condition was such that surgical intervention would have been undertaken at a great risk.

Adequate exposure of the lesion is a problem which confronts radiotherapists. Much can be accomplished by the careful and delicate use of the proctoscope and anal scope. In this regard the consulting proctologist can be of great assistance to the radiologist.

The accurate application of the radium tube and its maintenance in position for the time required is another problem to be overcome. The exposure furnished by the use of the endoscope is fairly adequate. Suitable instruments for holding the radium applicator in position, packing instrument, and vaseline gauze are necessary in the technic. The rectal lumen is filled or suitably packed with vaseline gauze (two-inch bandage). This is tolerated by the patient with a fair degree of comfort. The usual general or local anesthesia is not necessary. One H. M. C. (Abbott) tablet, No. 2, given twenty or thirty minutes before the placing of the radium, produces anesthetic somnolence and thus the necessary manipulation of the part in placing the radium is less painful and the treatment better tolerated.

While the number of cases (four) reported here is small, it is nevertheless representative of the operable lesions. It was obvious that the technic used in the man-

agement of the inoperable cases would not apply to these. The lesions were small and seemingly localized. Every endeavor had to be made to deliver a therapeutic dose, and to avoid the possibility of an irradiation proctitis. The interstitial method of placing a uniform dose in the malignant area was employed in one case.

REPORT OF CASES

Case 1.—A woman, aged 29, registered at the Mayo Clinic October 22, 1923. Her mother had died from "cancer of the intestines." The patient had been married six years and had not been pregnant. Menstruation was normal. Tonsillectomy had been performed in 1921. About six weeks before examination she first noticed a little bleeding at stool; the amount gradually increased, with a sensation of rectal fullness. Examination by her family physician revealed a rectal tumor; it was not painful. She had been nervous and cried easily.

On examination the patient weighed 128 pounds. A rounded tumor, 6 by 8 cm., was palpated on the posterior wall of the rectum, about 3 cm. above the anus and extending up just above the first valve (Fig. 1). Laboratory data were negative.

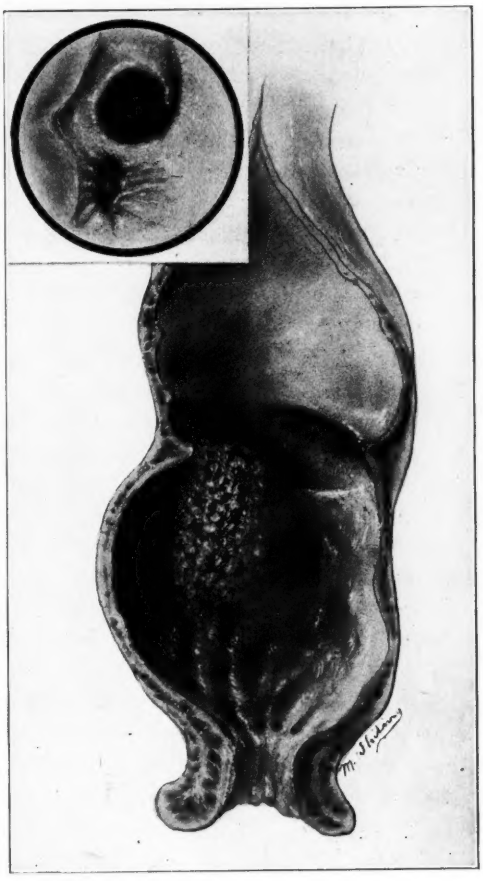

Fig. 1. Carcinoma of the rectum (Case 1) before radium applications were made. Insert shows an ulcer at original site of tumor and an area of contracture of the rectal wall following treatment.

A one-stage posterior resection (Kraske) was recommended. The patient had been told before coming to the Clinic that radium could be used, and operation avoided. She dreaded possible colostomy and the thought of losing sphincter control, and preferred to place these procedures as far as possible in the background. After the radiologist had been consulted it was decided to apply radium cautiously and to avoid, if possible, further rectal damage, and elements of risk to the operation should this be necessary later. A minimal amount of irradiation was also considered from the standpoint of the conservation of ovarian function. The first radium was administered October 28 by applying two universal silver tubes containing 50 mg. each of radium sulphate (element), placed tandem in a tubular Para rubber wall applicator, walls 1 cm. thick and 8 cm. long. The radium was filtered through the silver wall of the tube, 0.5 mm., 1 mm. of brass, and the rubber wall mentioned. The tubes were maintained in position twelve hours. A second treatment was given November 1, ten steel alloy needles containing 10 mg. of radium sulphate (element) being introduced into the tumor. Each needle was placed in a field about

2.0 cm. in diameter. The needles remained in place thirteen hours. A pathologic specimen was diagnosed "carcinoma."

Low irrigations were recommended to keep the treatment field clean and the ordinary measures instituted to prevent constipation. Within ten days a mucous discharge and serious rectal tenesmus developed. Post-treatment effects were distressing. Proctoscopic examination December 4 showed that the original tumor had entirely disappeared from within the bowel, an ulcer 1 by 2 cm. remaining at the site of the former growth. There was a mass under the left rectal wall about 7 cm. in diameter.

The patient returned to the Clinic January 24, 1924, stating that the rectal area treated was painful, especially at night. The mucous discharge from the rectum had decreased. Bowel movements were satisfactory and not painful. A slight amount of old blood had been seen in the mucus about three weeks previously but none since. Amenorrhea for the last two months and mild menopausal symptoms were noted. The weight had remained the same. The general condition was good. Rectal examination revealed an area of scarring at the site of the old lesion, with puckering of the whole thickness of the rectal wall and contracture of the rectal lumen to about 40 per cent of normal. The induration at the site of the old lesion was reduced about 50 per cent. Proctoscopic examination was painful and slight bleeding occurred. At the site of the original tumor was a small ulcer measuring about 1 by 2 cm. The tissues appeared edematous. It was decided to continue with local cleansing measures; active measures were contra-indicated.

May 20 the patient felt well, and experienced but little discomfort in the rectum. Occasionally brownish mucus was passed with the stool. She weighed 130 pounds. Several shotty, slightly tender inguinal nodes were palpated. Clinically these were considered as metastatic tumors. Rectal examination revealed a stricture of the lumen of the bowel and further reduction of the mass, probably another 10 per cent. On proctoscopic examination a slight change in the treatment field was noted. The margins of the ulcer were slightly proliferated.

One light application of radium to the rectum and prophylactic radium surface packs, applied to the right and left inguinal areas, were recommended. The universal silver tube was applied for four hours, vaseline gauze packing being used to hold it in position. Each inguinal area was marked off into six squares, each measuring about 4 cm. To each area the universal silver applicator, filtered through 2 mm. lead and 2 mm. Para rubber and maintained at 2.9 cm. distance by the interposition of a balsa wood block (2.5 cm. thick and measuring 3 by 4 cm. at the base), was applied for periods of from fourteen to twenty hours.

August 5, the patient complained of slight bleeding and mucous discharge. Her health had been excellent. Amenorrhea persisted; however, only slight menopausal symptoms were present. Rectal examination was not painful. The extrarectal mass was smaller. The walls were more relaxed; evidently there was less obstruction. Proctoscopic examination showed very little, if any, change. The size of the ulcer was about the same. Another four-hour rectal application was applied with the same factors. The tenderness, and the size of the inguinal nodes were so reduced that further treatment to these areas was considered inadvisable.

October 7 there were practically no symptoms. A small amount of blood was sometimes seen in the stool. The diameter of the formed stool was normal. In general, the patient was feeling well. Slight menopausal symptoms were present. Rectal examination revealed no activity; however, there were two areas of ulceration—the site of

the old tumor and one small area just above it. Radium treatment was not advised.

The patient was examined February 25, 1925. Her general health had been good. She was slightly constipated and a small amount of mucus and bleeding persisted. The lesion felt definitely active and inspection showed carcinomatous tissue in the field of treatment. A specimen revealed adenocarcinoma, graded 2. The extrarectal mass had not increased in size. The activity seemed to be superficial. The patient was anxious, realizing in a measure that the tumor area was active. Radium was applied with the understanding that she was to return soon for observation. A dental mold was made to fit the lumen of the bowel, and to this was strapped in a group (parallel) five steel alloy needles each containing 5 mg. of radium sulphate (element) and placed in one position for six hours. One day later, the same applicator was applied to an adjacent area for the same length of time.

The patient returned June 19 instead of on the date designated. The constipation had increased. The general condition remained excellent. Rectal examination showed that the rectal infiltration had increased 20 per cent. The rectal stricture did not admit the first joint of the index finger. The inguinal nodes were definitely enlarged and tender. One node, about 1 cm. in diameter, was easily palpated on the right side. On the left side there was an indefinite area of infiltration about 3 cm. in diameter. It was grossly evident that palliation was all that could be expected. Radium treatments were persisted in. Proctoscopic examination showed an increase in active tumor tissue and greater contracture of the bowel. On three occasions the universal tube was used with the added filtration of 1 mm. brass and 2 mm. aluminum; time of application, four hours. Three areas were treated. The vaginal cavity was also packed, using the vaginal applicator, as described in the treatment of carcinoma of the cervix uteri.[2] Three such treatments were applied. Six hours of treatment for each area instead of the usual fourteen hours was given. The vaginal cavity was small, and it was impossible to pack off adjacent vaginal walls. The inguinal nodes were exposed to radium, as mentioned previously.

August 31, 1925, the patient complained of great nervousness, insomnia, anxiety, depression, and weakness on slight exertion. There was no menstrual flow. Constipation had increased and the diameter of the stool was smaller. She now weighed 138 pounds. The constricting area admitted the index finger, and there was no bleeding or pain. The inguinal nodes were much smaller and clinically seemed inactive. Proctoscopic examination did not disclose activity (Fig. 1); however, the constricted area was definitely ulcerated. October 26 the patient was aware of slight tenderness in the right inguinal area. Her anxiety had induced her to palpate tender areas on the body and then worry about their relation to the rectal tumor. Her general condition was good. Palpation of the rectal tissues revealed definite metastatic nodes outside of the original field of treatment. Several were found back of the rectal wall between the original growth and the anus. One was ulcerating superficially. Inguinal nodes were clinically active and tender to only slight palpation. The largest node measured 1 cm. in diameter. The prognosis was bad and treatment was directed only to the endeavor to keep down the superficial activity and the ulceration.

From this time on the course was steadily downward. Infiltration of the anal tissues and buttocks made bowel movements painful and difficult. A rectovaginal fistula was present. Colostomy was performed

[2]Bowing, H. H.: Surgery, Radium and Roentgen Rays in the Treatment of Carcinoma of the Cervix. Am. Jour. Obst. and Gynec., 1926, XI, 400-403.

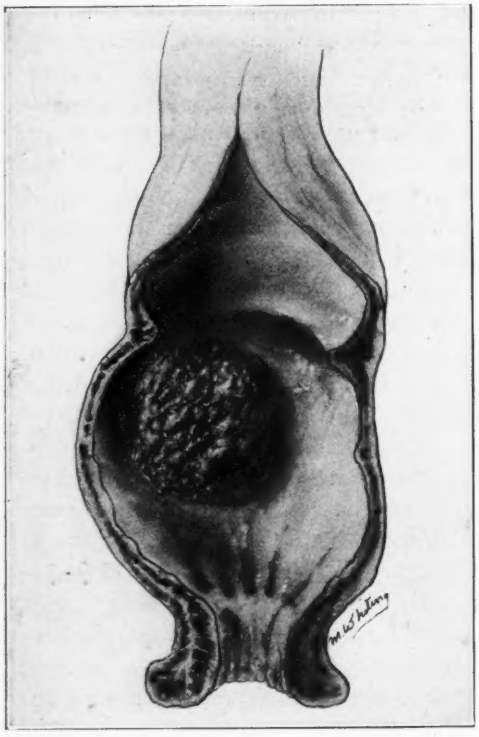

Fig. 2. Carcinoma of the rectum (Case 2) before radium applications were made.

March 17, 1926. Abdominal exploration did not reveal metastasis. The growth was free just below the uterus. The inguinal nodes enlarged gradually. Multiple metastatic masses developed in the abdominal wall, especially in the lower left abdominal quadrant. Secondary infection was a complicating factor. The patient died June 22.

Case 2.—A man, aged 52, registered at the Mayo Clinic December 28, 1923. His mother had died from cancer at the age of 54; a maternal aunt died from cancer, and a maternal uncle died from cancer of the rectum. The patient had had syphilis at the age of 22, and recently the blood Wassermann test had reacted positively. During the last year there had been a little blood and mucus from the rectum on two occasions. For four months a little bloody discharge had followed each bowel movement. Three weeks before examination a specimen had been removed and the pathologist had reported "adenocarcinoma."

The patient appeared generally well. Rectal palpation revealed a freely movable medullary tumor about 5 cm. in diameter on the left lateral wall. There were several small nodules easily palpated in the surrounding bowel wall. Proctoscopic examination revealed a carcinomatous mass about 5 cm. in diameter on the anterolateral rectal wall, at the level of the first valve (Fig. 2). The blood Wassermann test was positive December 29, 1923. Clinically there were signs of cardiovascular damage and antisyphilitic treatment was recommended in conjunction with the irradiation. The patient was anxious to retain sphincter control. The initial radium treatment was applied January 3, 1924; three universal tubes were placed in three crevices of the tumor. The radium was filtered through the wall of the applicator (0.5 mm. silver); the tubes were retained twelve hours. The rectum was packed with vaseline gauze. An interval of eighteen days was allowed to determine the tissue response. The tumor was reduced in size from 60 to 70 per cent and there was little, if any, palpable infiltration. Mucous discharge had increased slightly, and there was mild tenesmus. January 21, two universal tubes were placed against the lesion; the time was reduced to six hours. A total of 2,400 mg. hours was given.

February 12, rectal symptoms were unimportant. There was a slight mucous discharge. Palpation of the rectal tissues, which was not painful, revealed a certain degree of perirectal infiltration which did not seem fixed. Proctoscopic examination did not show evidence of carcinoma. An ulcer 3 by 1.5 cm. occupied the former site

of the tumor. There was considerable proctitis and perirectal induration; the lumen of the bowel in the treatment field was reduced. Active measures did not seem to be indicated.

The patient returned to the Clinic April 8. He had been somewhat constipated for two months. Since his last visit he had kept fairly quiet; activity tended to increase the mucous discharge. Blood had been noted occasionally in the mucus. The patient had no pain, although he complained of feeling tired most of the time. He had lost about 4 pounds in weight.

Examination revealed perirectal infiltration which was firm and fixed and reduced the lumen of the bowel to about 1.5 cm. in diameter. Examination was not painful. On proctoscopic examination the rectum was found to be surrounded by a fixed mass, most marked on the left. The rectal lumen was 1 cm. in diameter. There was a large ulcer 2 by 4 cm. on the anterior and left rectal walls, and adherent to the fixed pelvic mass. The stricture began at the first valve and extended up about 6 cm.

A surgical consultant recommended colostomy, abdominal exploration, and possibly posterior resection. A left modified Mixter type of colostomy was performed April 12. The area of infiltration in the rectum was extensive; it reached to both sides of the peritoneal fold in Douglas' cul-de-sac and could not be satisfactorily removed from above. Metastatic nodules were not palpable in the liver or regional lymph nodes. The convalescence following this was satisfactory, and a posterior resection was performed April 29. The tumor was situated in the upper part of the rectum and extended up to the line where the peritoneum is reflected onto the rectum in Douglas' cul-de-sac. It was necessary to open the peritoneum widely. The entire rectum, and probably a piece of the rectosigmoid was resected. The operation was difficult, owing to previous radium treatment and infection. No lymphatic involvement could be demonstrated. A pathologic specimen showed necrotic ulceration and extensive fibrosis. A few cancer cells were found in the fibrotic tissue, none in the ulcer. Probably the carcinoma had been almost completely destroyed by the radium. Convalescence was uneventful. The patient has revisited the Clinic on several occasions since the operation. When he was last seen, June 30, 1926, his general condition was good. Physical examination did not reveal activity in the operative field.

Case 3.—A man, aged 56, came to the Mayo Clinic January 19, 1924. For the last three or four years the patient had noticed the passage of small quantities of blood from the rectum, especially following a cathartic. About three months before his examination the rectum began to protrude; there was much itching and some blood. His physician found and removed a polyp. This was reported to be non-malignant. Later, when he was examined, the previous operative field had healed, but higher up an "ulcerating area" was found and a diagnosis of carcinoma made. Radical operation was advised but was refused. Six roentgen-ray treatments, twenty-minute doses over the sacrum, were given with but slight response.

On examination at the Clinic a plaque-like infiltration about 5 cm. in diameter was found on the left rectal wall. The lesion on the left rectal wall was just above the anus. Adenocarcinoma was diagnosed from a specimen. Radium and roentgen-ray treatment was advised, the patient to remain under continued observation.

January 25, two universal tubes, as previously described, were applied to the upper half of the lesion (the silver wall of the applicator, 0.5 mm., Para rubber tubing, walls 0.2 mm.; time seven hours). The second treatment was applied, January 28, to the

Fig. 3. Carcinoma of the rectum (Case 3). One series of roentgen-ray treatments had been given previously (elsewhere). Insert shows grayish plaque-like area occupying site of original tumor; typical treatment effect.

lower half of the lesion, the same factors being used except that the time was ten hours. Vaseline gauze was employed to pack off the normal bowel wall as well as to hold the applicator in position. In view of the possibility of metastasis to the inguinal nodes these areas were exposed to radium surface packs, as described in Case 1.

Proctoscopic examination, February 7, showed reduction of the lesion from 30 to 40 per cent. Some bleeding was noted and there was gross evidence of activity. February 8, two universal tubes were applied to the surface of the lesion for seven hours. February 19, dissolution of the tumor seemed complete. Ulceration and some proctitis extending up to the second valve on the left wall were noted.

Roentgen-ray treatment was given February 25, with the high voltage technic. The treatment factors were: kilovolts 200, distance 50 cm., ma. 5, filtration copper 0.75 mm. and aluminum 2 mm., time one hour and thirty minutes, on one posterior area 20 by 20 cm. April 7, there were no rectal symptoms; however, immediately following the treatments there had been a slight increase in mucous discharge, and mild tenesmus. Local cleansing enemas afforded relief. Proctoscopic examination revealed a grayish ulcer about 1 by 2 cm., replacing the original lesion, a typical treatment effect. There was no evidence of malignancy (Fig. 3). April 29, slight induration was noted; the ulcerated area was smaller. The true nature of the induration could not be determined. Radium was applied; time three hours.

May 12, the ulcer was about 1 cm. in diameter. The patient has been under observation from time to time. In a letter from him (October 13, 1926) he said he was at work and that the treatment field seemed quiescent.

Case 4.—A man, aged 75, registered at the Mayo Clinic June 29, 1925, complaining of bleeding from the rectum. The patient's mother had died from cancer of the bowel at the age of 87. He had had hemorrhoids in 1881. Later he had been constipated, but for three or four years this had been corrected by dietary measures. In the last year, however, he had taken laxatives

daily. For about nine months there had been slight soreness in the rectum, a bloody discharge with bowel movements, and blood passed from the rectum during straining at the time of urination. Frequency had been present during 1920. In 1924 he voided two to five times at night and every hour during the day.

The patient's general condition seemed good. He weighed 158 pounds. The systolic blood pressure was 120, the diastolic 80, and the pulse rate was 70. Arteriosclerosis was graded 3. A tumor about 6 by 8 cm. was present on the posterior wall of the rectum. Benign hypertrophy of the prostate, graded 3, was noted. Urinalysis on two occasions showed moderate albumin and pus graded 2 and 3. Residual urine was found on two occasions. The phenolsulphonephthalein test showed a return of

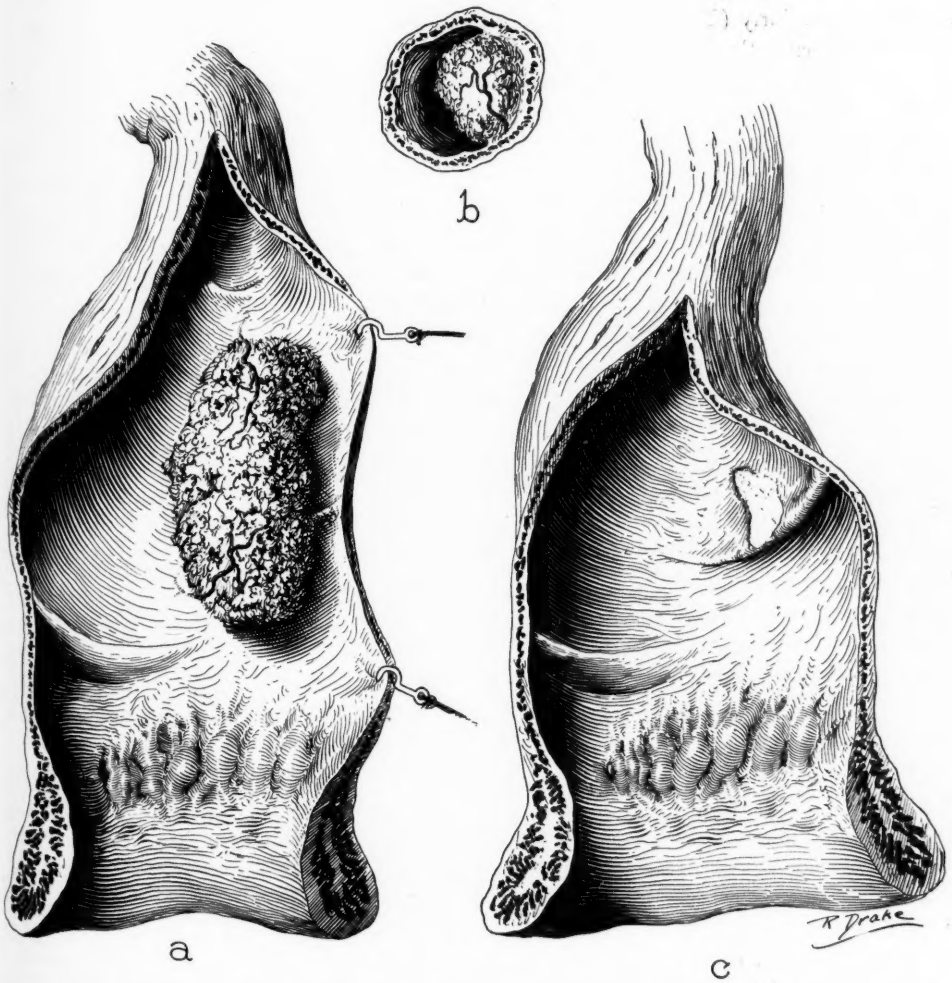

Fig. 4. *a*, Carcinoma of the rectum (Case 4) before treatments were instituted; *b*, neoplasm in cross-section of bowel; *c*, a typical grayish plaque-like area occurring at the site of the original lesion following treatment.

35 per cent. The blood urea was 28 mg. for each 100 c.c. Roentgen-ray examination of the chest was negative for metastasis. Proctoscopic examination disclosed a large operable carcinoma involving the middle third of the rectum (posterior half) adherent posteriorly (Fig. 4, *a* and *b*). Because of the patient's age, the severe arteriosclerosis, prostatic hypertrophy and urinary findings, irradiation was recommended.

The first radium treatment was given July 3. The universal tube previously mentioned was applied to the lower fourth of the lesion with the following factors: filtration, the wall of the applicator (0.5 mm. silver), brass 1 mm., aluminum 2 mm.; time six hours. The second treatment was given July 6 to the lower middle fourth of the tumor, and the third was given July 9 to the upper fourth of the tumor.

July 14, surgical diathermy was used. The equipment employed was the portable type with a three-stage Tungsten-point spark-gap and a five-point rheostat control. The transformer was of the dry type depending on air and spacing for insulation. The condensers were triple and of solid mica plate. The alternate current was 110 volts, 60 cycle. The active electrode was a piece of music wire, gauge No. 23, 31 cm. long, sharply pointed at one end and bent at a right angle 23 cm. from the point. The blunt end was fastened into the coagulating handle. The indifferent electrode was a piece of block tin and a gauze pad well saturated with a concentrated sodium chloride solution, and both were fixed to the lumbosacral area. The machine set-up was as follows: rheostat pole No. 3 with three stages of the spark gap slightly open. The active electrode was introduced through a proctoscope into the tumor, and the current turned on until about 1 cm. of tissue was coagulated. In this manner multiple areas were coagulated. No anesthetic was employed. The second bipolar diathermy treatment was given July 20. Inspection revealed that 90 per cent of the tumor was necrotic, and an endeavor was made to coagulate the remaining active areas. The fourth radium application was made July 23, to the upper middle fourth part of the tumor. The fifth application, July 27, was made to the middle of the tumor.

As a prophylactic measure, the right and left inguinal areas were exposed to radium surface packs, as in Case 1.

Proctoscopic examination, August 4, showed that the carcinoma had been replaced by an ulcer about 5 cm. long (stellate). Only one small area suggested malignancy, possibly granulated tissue.

The first roentgen-ray treatment was given August 6 (kilovolts 200; distance 50 cm.; ma. 5; filtration copper 1 mm. and aluminum 1 mm.; time one hour and fifty minutes each, to the anterior and posterior areas, 20 by 20 cm., and two lateral areas, 10 by 20 cm.).

November 4, the patient reported having seen a small amount of blood in the stools on two occasions since treatment. No vesical symptoms were noted except occasionally slight burning on voiding. His general condition was excellent. Rectal examination disclosed a lesion too high for satisfactory palpation, and slight induration. Proctoscopic examination did not reveal evidence of malignancy; only a small ulcer replaced the former lesion (Fig. 4, *c*).

On examination, May 28, 1926, conditions were satisfactory. November 8, the patient reported that six weeks before, lifting a wash tub had started slight rectal bleeding, which had continued. There was, however, no rectal discomfort.

Rectal examination was negative. The prostate seemed to be reduced 50 per cent as the result of the irradiation. There was a typical area, about 2 by 1 cm., of reaction to radium on the posterior wall of the rectum about 18 cm. above the anus, which

bled freely on slight trauma. There was no gross activity in the field of treatment. The function of the rectum was normal. Initial results were thus far satisfactory. A continuation of local cleansing measures was recommended.

Owing to the presence of a node 1 cm. in diameter in the left inguinal area and tenderness to moderate palpation, a roentgen-ray treatment was recommended (kilovolts 135; distance 16 cm.; ma. 5; filtration aluminum 6 mm.; time thirty-five minutes).

DISCUSSION

There are other case histories in our files of equal interest. Those recorded are typical of the early or operable group. They are few in number and therefore valueless

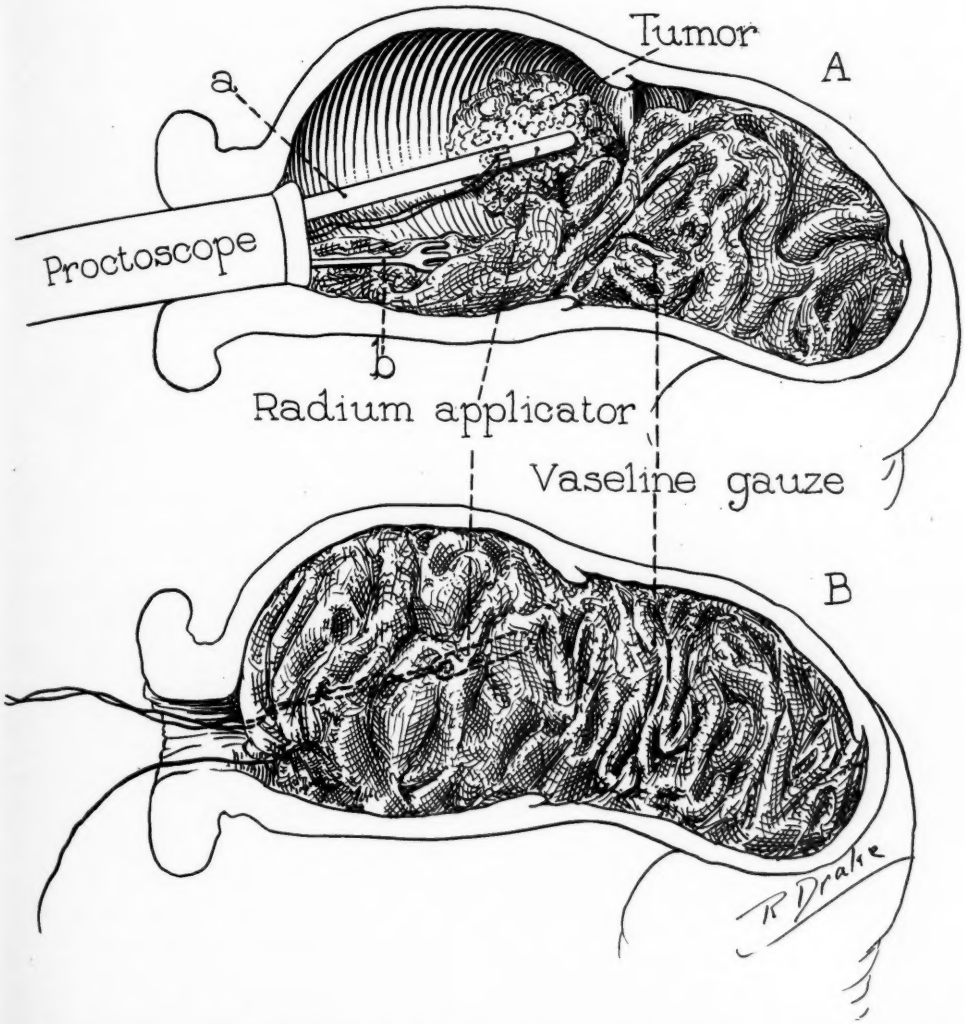

Fig. 5. Semidiagrammatic drawing illustrating the important features in the technic employed in the radium treatment of early operable cases of carcinoma of the rectum.

from the standpoint of statistical data. The treatment has been recorded in detail for the purpose of analysis, and for consideration in the treatment of early cases in the future. Early lesions of the adenocarcinomatous variety will respond to radium surface treatment. Applications should be made carefully, preferably by direct vision (Fig. 5, *a* and *b*). The treatment time must be reduced from that recorded here; probably four hours will suffice, depending on the thickness of the lesion and the filters employed. One millimeter of brass and 2 mm. of aluminum or Para rubber seem to be indicated. The applicators should be accurately placed and maintained for the allotted treatment time. Only one tube applicator should be used at any one time. The broken dose, that is, an interval of three or four days between applications, will furnish an index to the individual response so necessary for good results. For bulky lesions, the electrothermic method seems to be superior to that of buried radium. It is impossible to cleanse the operative field sufficiently to employ surgical procedures necessary for the introduction of the radium needles. It is also impossible to keep the field surgically clean enough to avoid secondary infection. Also a certain amount of trauma is unavoidable and there is a possibility that carcinoma cells may be disseminated. Evidently, coagulation has a definite but limited place in the treatment. Certainly it is a satisfaction to get rid of the bulk of the tumor in order that radium may be applied to its base. In this way the number of applications is reduced and the chance of over-irradiation of normal bowel diminished; this is important, especially if colostomy is to be avoided. Colostomy is desirable from the therapeutic standpoint, chiefly because it puts the treatment field at rest and permits greater cleanliness, thus minimizing the possibility of secondary infection. There is a risk attached to the operation as well as to the restoration later, should the response to treatment prove satisfactory. As a rule, patients dread the operation, and there is evidence to indicate that effective treatment can be given without it.

The proctoscope is as important in treatment as it is in examination. It is employed in practically all applications of radium to the rectum. It furnishes good exposure of the part treated and permits accurate placing of the applicator as well as the vaseline gauze packing. The latter has proved the most satisfactory packing material; it is easily placed, well tolerated, and very little discomfort is experienced when it is withdrawn. With the endoscope introduced, and the patient in the knee-chest posture, the rectal walls are distended so that the cavity may easily be filled with the packing material. At each application the normal rectal walls should be packed away as much as possible from the applicator. The applicator is held in position with an especially designed instrument (Fig. 5, *a*). The packing is placed with a Kelly uterine packer (Fig. 5, *b*). To lengthen the instrument the handle is inserted into a suitable piece of brass tubing.

At the completion of the procedure, two strings protrude from the rectum, one attached to the radium tube and one to the proximal end of the vaseline gauze packing. These ends are fixed to the sacral area with adhesive plaster. As a rule the radium applicator and the packing are well tolerated by the patient. It is essential to avoid packing the anal canal. Between treatments and as a post-irradiation measure, the patients are instructed to keep the part clean by lukewarm water enemas until the water returns clean.

Roentgen-ray treatments have a definite place in the therapeutic management and, as in radium treatments, judgment has been

gained through experience in treating the inoperable case. It seems reasonable to conclude that measures must be taken to deliver a dose which will supplement the radium effect on the tumor and save the rectal walls from unnecessary damage. Rectal carcinomas are known to remain local for long periods. This, combined with the finding of early localized lesions, should govern our actions in outlining radical roentgen-ray treatment for a given patient.

The patient must be kept under periodical observation; in this way recrudescent areas are found before the patient has a chance to complain of them. As yet, it is impossible to outline the best procedure when activity is found at subsequent visits. Much depends on the local findings and the possible chance of extension. The patient in Case 1, for example, had definite metastasis to the inguinal nodes in the early months after treatment, so that, at best, palliation was all that could be expected. There is much to commend radical surgical methods rather than to persist with irradiation. In this event, the operative specimen furnishes valuable information, and abdominal exploration furnishes excellent data on which to establish future treatment.

Given an early case, for example, similar to Case 3, cautious radium treatment should be applied with the universal silver tube, as described, with added filtrations of 1 mm. of brass and 2 mm. Para rubber; time four hours. After an interval of three or four days, and observation of the treatment field, the application should probably be made to a different area or surface of the tumor. It is impossible to determine in advance the number of applications. However, as soon as the surface of the tumor shows the typical radium effect, applications should be discontinued and the area again observed in from seven to ten days. The four-hour treatment time would have to be changed to meet the local condition and a reduction would be anticipated. After the radium has been applied, all factors should be considered and a suitable roentgen-ray regimen instituted. For bulky lesions similar to that in Case 4, electrothermic methods, as described, should be used to reduce the bulk of the lesion in a fairly rapid manner in order to permit the application of radium.

Proctoscopic observations should be persisted in throughout the treatment time and at frequent intervals during a careful follow-up period, which should be carried on for several years, at first every few months and, finally, once a year.

FURTHER OBSERVATIONS ON THE ROENTGEN-RAY TREATMENT OF BRONCHIAL ASTHMA AND ALLIED CONDITIONS[1]

By ISAAC GERBER, M.D., PROVIDENCE, RHODE ISLAND

ABOUT two years ago, in a previous communication, attention was directed to the roentgen-ray treatment in true bronchial asthma and various types of chronic bronchitis. Since that time further experience has shown that the method has a real place in therapy.

In the treatment of bronchial asthma, the first and most important consideration is the matter of diagnosis. It is extremely important that the treatment be limited to cases of true bronchial asthma; otherwise unnecessary treatment is apt to be applied with no beneficial results. Numerous cases of supposed bronchial asthma have been proved later to be merely cardiac asthma or simple bronchitis without complications. The essential element is the proof that we are dealing with a true protein intoxication. Of course, it will be urged that in these cases the newer and more modern methods of treatment, such as vaccination, etc., should be used. This is quite true, and, in fact, the vast majority of cases that have come to my attention for treatment have been those in which all the modern methods have already been applied but without any real lasting benefit. Many were cases in which numerous operations had been performed, particularly in the upper respiratory tract.

In selecting the cases for treatment a careful study of the sputum is often important. Those patients who have the characteristic elements in their sputum, such as pearl bodies, Curschmann's spirals, and eosinophiles, are apt to be most responsive to roentgen-ray therapy. Cases which already have marked emphysema, and particularly hypertonia, are least benefited. However, treatment should not be withheld from even these terminal types, as there is no danger of making the condition worse if the treatment is applied cautiously. No estimate as to prognosis can be based upon the blood examination alone. Some of the observers have felt that individuals with high eosinophile counts in the blood would respond better to X-ray treatment than those without. The careful work of Schilling shows that this idea has no real foundation. The matter of duration of the disease also is of little help in prognosis. Many cases of years' duration have reacted as well or better than others of short duration. This does not of course apply to old cases with emphysema. When the latter is present as a complication the condition is usually refractory.

I have previously described the two methods of treatment with X-rays, the direct and the indirect. In the first, the rays are applied directly to the chest. In the indirect method, the rays are applied to distant regions, such as the spleen, the pituitary, adrenals, etc. There is no unanimity of opinion in the current literature as to the best method of treatment. Klewitz in his most recent contribution has reported 121 cases, all of them treated by the direct method alone. He claims 30 per cent of permanent improvement and altogether 81 per cent in which there has been either partial or complete relief from the asthmatic paroxysms. These figures are very striking and, indeed, somewhat better than the results of other authors. The general average is 75 per cent of partial or complete relief.

With regard to the indirect treatment, the chief method of application has been to

[1]Read before the Twelfth Annual Meeting of the Radiological Society of North America, at Milwaukee, Nov. 29–Dec. 4, 1926.

the spleen. This was worked out by Groedel, whose results seem to be about the same as those reported with the direct treatment. In the past two years I have gradually become convinced that it is not necessary to treat all the cases of asthma over the spleen. Bergerhoff is of the same opinion and feels that it is entirely irrational to submit a perfectly healthy organ to such uncertain influences as roentgen rays in the hope of affecting a far distant pathological process. On the other hand, I have felt that in those cases which were refractory to the direct type of treatment over the mediastinum, it was worth attempting the indirect method over the spleen in the hope that further benefit might be obtained. In several cases I have found this sequence very useful.

Other methods of indirect treatment have been advocated by various investigators, particularly Ascoli. He has published the results of treatment in five cases of asthma wherein the rays were applied to the pituitary body, through the forehead and temporal regions. His results as reported are not very convincing. In fact, they are not more convincing than the claims which have been made for pituitary treatment in a variety of other diseases, such as deafness, psoriasis, etc.

The clinical results of the X-ray treatment have impressed me as being usually quite definite. In many instances there is an initial increase of expectoration or perhaps an increase in the number or severity of the asthmatic paroxysms. This is promptly followed in the favorable cases by a lessening of the cough, a diminution of expectoration and gradual amelioration or perhaps entire disappearance of the spasms. The clinical response varies greatly in different patients, and one can never attempt a prognosis on the basis of the patient's clinical condition.

In my previous paper I considered Groedel's theory that the character of the patient's response to treatment ran more or less parallel with the severity of his general constitutional reaction following the treatment. At that time I thought that this had been true with my own cases. At present I believe that the occasional reaction which comes on after X-ray treatment, consisting of general prostration, nausea, vomiting, rise of temperature, and perhaps diarrhea, is due largely to two factors. One is the application of a large dose of rays to the mediastinum; the other is the splenic application itself. Exposures to the spleen are much more apt to bring on these general reactions. With a cutting down of the mediastinal dose to 20 per cent or less of the skin erythema dose instead of the 30 to 50 per cent advocated by many of the writers, and a restriction of the splenic exposures to the more refractory cases, I find that there is much less general reaction, even in those cases which progress very steadily and favorably. I have noticed several other types of reaction, however, which are not serious. In several instances an acute attack of urticaria has followed the first or second application of rays. This is obviously a manifestation of an anaphylactic condition and is not essentially different from the bronchial spasm which exists in the true asthmatic paroxysms. In two cases, attacks of herpes zoster took place, apparently extending from the sections of spinal roots which had been exposed to the rays. In one such case the attending physician suspected that an X-ray dermatitis had been produced, but the type of lesion, the radiation along the intercostal spaces, and the course of the disease demonstrated clearly that it was zoster. Besides, the lesions appeared only three or four days after the X-ray exposures.

In some instances extremely spectacular results have followed the treatment. One of the worst cases I have treated was that of a woman who had become so thoroughly

accustomed to adrenalin that she had used up two hundred bottles in four years, an average of about one bottle a week. She required extremely large doses to control her paroxysms, as much as a half dram to one dram subcutaneously. This patient had a severe general reaction with even a small dose of X-rays, so that the treatment had to be extended over a considerable period of time. Eventually, however, she was made very comfortable and was able to do without adrenalin for long periods of time.

The X-ray treatment of bronchial asthma is not brought forward as an absolute cure for bronchial asthma. Some of the cases I have treated did not show any further paroxysms for two years after a single course of treatment. In many others there has been benefit of more or less duration, which could be kept up by judicious repetition of treatment with smaller doses. The rays must be applied here very much as any other therapeutic agent. It is not merely a problem of applying a particular dose of the physical agent in a case of asthma, but the treatment must be individualized. The art of therapy must be utilized just as well as the scientific aspect.

With regard to technic, Klewitz has always insisted upon the importance of strictly following his particular method, with four fields on the back of the chest and three fields on the front, omitting the cardiac region. Each area receives a third of an erythema dose, with one or two portals exposed each day. Short wave length rays are used, with copper or zinc filter. It takes from three to seven days to complete one series of treatments, and this is repeated in from four to six weeks whether there is any benefit or not from the first series of treatments. The beneficial effects of Klewitz' method, as shown by his superior statistics, are probably due largely to the fact that he repeats with a second series regardless of the effects from the first series. Many workers have omitted the second series and perhaps their poorer results may be due to this omission. Marum and Bergerhoff have both modified Klewitz' technic, and use single front and back areas with short wave length therapy. Each area is fairly large, either 10×15 cm. or 20×20 cm. Both of these workers employ smaller doses, Marum using 1/5 and Bergerhoff 1/4 of an erythema dose.

In my own practice I have attempted to utilize the best points of all the published methods. At present I am employing routinely two portals of entry, front and back, over the mediastinum. Each area is 10×15 cm. or 20×20 cm., depending upon the size of the patient; usually the smaller area is sufficient. Over each area about 15 to 20 per cent of a skin erythema dose is applied, with short wave lengths at 50 cm. distance. This is somewhat smaller than the dose administered by most of the European radiologists, but I find that it serves the purpose just as well. If I do not obtain any beneficial effect from the treatment, I then radiate the spleen with a similar dose, applied to the front. This course is to be repeated in from three to six weeks. Only one area is treated at a time and the exposures are made on successive days if the patient's condition permits. If there is any severe reaction, a day's interval is allowed between the treatments. This rule cannot always be followed absolutely, but must depend more or less upon the general clinical condition of the patient. The more vigorous patients can stand treatment more intensively applied. Weaker patients, who have had the disease for a long time, must be treated with smaller doses at longer intervals.

No thoroughly satisfactory explanation has as yet appeared regarding the mechanism of action of the X-rays in this condition. Previously I outlined the various theories explaining the action and showed

that it was the general consensus of opinion that the direct methods of treatment had their effect through a shrinkage of the tracheal, mediastinal, and hilar lymph nodes, and that this eventually resulted in a disappearance of the irritation of the fibers of the vagus system. Some of the recent writers, particularly Bergerhoff, still adhere to this theory. Unfortunately my own experience does not support this view. There are many instances of patients with true bronchial asthma in whom a careful X-ray examination does not disclose any definite enlargement of the hilar or tracheo-bronchial lymph nodes. On the other hand, many cases that showed an enlargement of these nodes, previous to the application of X-ray treatment, did not show any appreciable change on their subsequent examinations. This failure to shrink was observed in many cases where clinically there had been an absolute cessation of all asthmatic symptoms. From my experience with lymph node enlargements in other types of chest pathology this situation does not appear strange. We must remember that enlargements of the lymph nodes in the chest are very unstable conditions and vary from day to day. Examination of a large series of cases with influenzal infection showed enormous changes in the appearance and size of the hilar nodes within twenty-four hours, varying with the conditions of the infection, temperature, etc. It is very probable that many of the enlarged nodes that we see in asthmatics have no connection with the irritation of the vagus system, but are entirely separate conditions resulting from chronic infection and other secondary factors.

My own feeling is that we have a better explanation in the point of view brought out by Hajos and later supplemented by Holthusen. They have called attention to the desensitizing effects of X-rays. We have known for a long time that X-ray treatment can produce analgesic effects in such conditions as pruritus, neuralgia, etc., and it has been supposed that this analgesic action was due to a lowering of the sensibility of the nerve endings in the skin. Some animal experimentation has been done along these lines, but it is not as yet very extensive. More work remains to be done. In asthma it seems quite possible that the rays may produce a similar lowering of sensibility of the terminal fibers of the vagus system, which are located in the field of exposure, and that this may eliminate spasms caused by various small stimuli constantly existing in the individual patient.

Another aspect which must be borne in mind is that the radiation is applied to the heart and great blood vessels as well as to the lungs and lymph nodes, and therefore during the period of treatment practically the entire volume of circulating blood is thoroughly exposed to the X-rays. We know that the leukocytes, and particularly the lymphocytes, are quite susceptible to this radiation. Under the circumstances numerous end-products of leukocytic degeneration are circulated through the entire body. Some of them may be antibodies or may be capable of producing antibodies which could affect the general condition of protein sensitization.

The study of the effect on the spleen when exposed to the rays is also interesting in this connection. The original work with the splenic exposures in asthma was based upon Stephan's early theory that treatment to the spleen might stimulate splenic activity and cause the production of antibodies in this organ. The investigations of the past few years make it seem improbable that we can "stimulate" splenic activity by any type of roentgen radiation. It is more probable that even the smallest of doses have paralyzing and destructive effects on the cells. The mechanism in the spleen is more apt to be the production of end-products due to

the destructive effects of the rays on the more sensitive cellular elements. Recently Gassul, of Leningrad, has been studying the effect of diathermy on the spleen. He has treated a large number of asthmatic patients in this way, and has found that many patients who did not respond to the usual methods of asthma treatment, and were refractory even to subsequent X-ray treatment, gave very excellent results when exposed to diathermy of the spleen. The only difficulty was that it required a long treatment daily, over a considerable period of time. The explanation of the treatment was the production of a hyperemia in the spleen from the diathermic current, which was supposed to increase the function of the spleen. Unfortunately the author felt impelled to enter into the field of speculation, assuming that the chief function of the spleen was the formation of antibodies generally. He concluded that the activation of the splenic function would result in a wholesale liberation of antibodies which might combat the particular anaphylactic condition causing the patient's bronchial asthma.

From the above discussion it is obvious that the theories regarding the action of the X-rays in this disease are still involved in a maze of speculation and that no really reliable explanation has been advanced. The important fact to be learned from the entire study is that the application of X-rays in the treatment of asthma is still largely empirical. We cannot guarantee a relief of symptoms by any type of preliminary estimation of the case. It is necessary to apply X-rays to the patient, carefully follow the clinical results, and repeat the treatment later if it seems desirable, basing one's further handling of the case entirely upon clinical evidences.

In the treatment of chronic bronchitis without asthma further experience inclines me to the belief that it is chiefly of advantage in children. The great majority of adults whom I have treated have shown rather doubtful results. It has been difficult to distinguish between results that were actual and those that were largely psychic. In children, on the other hand, I have felt that the results were really quite definite. The treatment has been especially valuable with the chronic coughs following whooping cough or influenza and mild grippe. Here we are dealing with patients who may have a chronic cough lasting for a period of weeks or months after the initial infection, without any apparent benefit from various types of treatment. In these cases the response to X-rays is sometimes spectacular. Very frequently patients have started to improve after the first application of the rays. In these cases it is not necessary to give large doses or to use the short wave length treatment. The longer wave lengths may be employed, with either three or four millimeters of aluminum as a filter, and 10 to 15 per cent of the skin erythema dose. With very young patients, especially infants, even smaller doses may be used, so that treatments can be given as often as twice weekly. The mechanism of action in these cases is also obscure, but it is possible that we may be dealing with a resolution of inflammatory exudates, which we know by the work of Fried and others will respond to the administration of very tiny doses of X-rays.

Whooping cough is a disease that I feel should be considered with bronchial asthma and chronic bronchitis, not because of any similarity in etiology, but merely because of its similarity in response to X-ray treatment. For many years the treatment of whooping cough has been very unsatisfactory, as shown by the extremely large number of therapeutic agents that have been advocated from time to time as a cure. In the past few years particularly, there has been a steadily increasing realization of the

seriousness of whooping cough, both with regard to mortality and to the complications that result. A satisfactory treatment would certainly be welcomed everywhere. I believe that the introduction of X-ray treatment in this disease by Leonard and his coworkers is a very valuable step in the right direction. The treatment has not been found of use as a prophylactic and is of no real benefit in the early stages of the disease. It appears to have its real application only in the second or paroxysmal stage.

The technic of treatment is simple. The front and back of the chest are exposed to the rays. A spark gap of seven to eight inches back-up may be used, with three or four millimeters of aluminum. A small dose, not over 7 or 8 per cent of a skin erythema dose, is sufficient. An exposure is made to both front and back of the chest at one sitting. Treatment is given every other day until a maximum of five treatments has been applied. If the patient is going to show improvement in his condition, he will show it by the fifth treatment; if not, there is no point in continuing the treatments. In the favorable cases an amelioration of the paroxysms will often be noted after the first application of the rays. As a rule, definite improvement is noted with the second or third treatment, and usually the patient is very comfortable by the time the entire series of five has been finished. In a small percentage of cases it is not necessary to give more than two or three of the treatments, as the patient may entirely stop his severe paroxysms.

It must be emphasized that as this method of treatment is not directed toward the etiological agent the actual disease is not eliminated. We merely produce an amelioration or disappearance of the distressing laryngeal spasms, which are often accompanied by vomiting and seriously affect the nutrition of the patient. The subsequent course with these patients will still show more or less cough, gradually disappearing. Later, if the cough is persistent, even without spasms, we may have the situation I described above when discussing chronic bronchitis in children.

Some observers have objected to the exposure of the thyroid during the treatment, contending that it was not wise to expose this organ to X-rays in growing children. This objection is easily overcome by covering the neck with a suitable lead or lead-rubber protection. This will not in any way diminish the benefit to be derived from the treatment. This treatment is especially valuable in the cases of whooping cough in young infants, where the prognosis formerly has been very bad.

In general, my experience has been that practically three-quarters of all unselected cases of whooping cough in the paroxysmal stage will benefit by X-ray treatment. Some of these will improve to only a slight extent, while others will benefit materially, or perhaps be entirely relieved of the distressing paroxysms. Approximately 25 per cent will be found refractory to the treatment.

This figure of 25 per cent corresponds very closely to the percentage of asthma cases that show no result from X-ray treatment, according to the collected figures of most of the observers who have published statistics during the past five years. This similarity makes me feel that there is possibly also a similarity in the mechanism of action of the rays in the treatment of whooping cough and bronchial asthma. We know that in whooping cough the site of the disease is largely in the trachea, particularly the upper portion, where the ciliated epithelium is invaded by the organisms. It is impossible that this particular site could be affected by the rays, as we do not usually expose this region during the treatment. In fact, this area is included under the lead covering when we protect the thyroid. In spite of this elimination of the

chief seat of the disease we achieve our result in causing the disappearance or diminution of the spasms. Under the circumstances, I am impelled to believe that we are concerned with the same mechanism as in asthma, probably a diminution of the sensibility of the vagus nerve endings and consequently a raising of the threshold of irritation necessary to produce a laryngeal spasm.

SUMMARY

In a previous communication, attention was directed to the value of roentgen-ray treatment in true bronchial asthma and various types of chronic bronchitis. Further experience has demonstrated that the method has a definite position in therapy. A careful diagnosis of true bronchial asthma is very important. Otherwise, unnecessary treatment may be applied without benefit. Direct treatment of the chest and mediastinal contents has been found generally more efficacious than the indirect treatment applied to other organs, particularly the spleen. Treatment to the latter is best restricted to the refractory cases. Routine treatment of the chest and mediastinum may be applied in small doses of short wave lengths, with only two fields, front and back. It is not necessary to employ the large number of portals advocated by Klewitz. No further positive information has been obtained with regard to the action of rays in this condition, but experience seems against the theory that the beneficial effects are the result of shrinking of the mediastinal and tracheo-bronchial lymph nodes. A more plausible theory is that of Hajos, that the diminution of paroxysms is the result of desensitization of the vagus nerve endings by the rays.

Roentgen-ray treatment of chronic bronchitis without asthma is more successful in children than in adults. It is especially valuable in the varieties following whooping cough and influenza.

The use of the rays in the paroxysmal stage of whooping cough is analogous to their use in bronchial asthma. The rationale of the treatment is probably the same. The paroxysmal stage of whooping cough can be either aborted or greatly relieved in approximately three-quarters of all cases.

DISCUSSION

DR. T. D. CUNNINGHAM (Denver): Dr. Gerber spoke about true bronchial asthma. I do not understand quite what he means by true bronchial asthma. Walker, of Boston, has divided asthma into asthmatic bronchitis and true bronchial asthma. True bronchial asthma, as I look at it to-day, is due to sensitization to proteins of the various types. The other type of asthma, the asthmatic bronchitis, is due primarily to infection. It has been my experience that the type that yields to the X-ray is that which is due to infection. That is more or less borne out by the percentages of relief gained from the use of the X-ray. However, when they start to treat bronchial asthma with the X-ray, they must take into consideration the pathology. The pathology of asthma is something about which very little is known. Koessler, of Chicago, wrote a very illuminating article on the pathology of asthma in the *Archives of Internal Medicine*, in 1922, and I would recommend that, if you are going to treat bronchial asthma with the X-ray, you read this article first and then realize that if you give sufficient treatment to cause the changes, to give the lung a more normal condition, you are going to cause severe changes, and a little overtreatment will make the condition of the patient much worse than no treatment at all. I think the paper is very valuable in offering another treatment, but I would advise a word of caution in the use of the X-ray.

DR. GERBER (closing): I have only a word to say with regard to my definition of bronchial asthma. I meant exactly what Dr. Cunningham referred to in Walker's classification. The cases of asthmatic bronchitis and other types of asthma due to infection have undoubtedly been included among the patients I have treated, but the results have been variable, and, as a matter of fact, men with the most experience in this particular treatment, like Klewitz, insist that the ideal case is the one in which you have definite clinical proof that you are dealing with a case of distinct sensitization to definite proteins. As for the seriousness of using the X-ray treatment, in view of the known pathology of asthma and its complications, I do not feel that we need worry about that. As I mentioned in my paper, I am not offering X-ray treatment as a substitute for other known methods of treatment. If there are other things that are simpler and which the asthmatic can obtain by definite therapeutic agents, well and good. The best of the men who are working in the asthma field exclusively assure me that they are running constantly into cases that go through their routine and receive no benefit, and that is the group to which I feel this method is to be applied. After all, this is an empirical treatment, there is no getting away from that: it is a treatment to be applied in a distinct group wherever simpler methods perhaps have been applied without avail, and where the patient demands and ought to obtain relief if it can be given to him. With regard to the matter of danger from the treatment, I feel quite confident that it is harmless when applied intelligently. No one has reported in the literature any permanent ill effects or anything that eventually made the patient worse. I personally have not encountered any definite damage to any patient. I do not employ the large doses that some of the Germans have used. As a matter of fact, one can obtain the desirable good effects of the rays from doses that are 15 or even 10 per cent of a skin erythema dose over each area. It must be remembered that we are not dealing with malignant disease but with a benign medical condition.

In treating asthma I prefer to use the short wave length X-rays with copper filtration because with this technic the desired dose can be given in the depths with a minimum of effect on the skin. Many of these sensitized patients have skin that is likewise more sensitive than normal. Under these circumstances I believe it is unwise to use the longer wave lengths with aluminum filters. After all, the treatment is a purely empirical method. I believe we can accomplish an immense amount of good for many of these wretched patients, with no risk, and with reasonable chances of success.

CHOLECYSTOGRAPHY: A SUMMARY[1]

By SHERWOOD MOORE, M.D., Associate in Surgery (Radiology), Washington University School of Medicine, St. Louis

So many publications dealing with cholecystography have appeared from the clinic of the Medical School of Washington University that it is with extreme diffidence that one appears before this Society to present another. There are at present in press, also, two articles by members of our staff, with complete résumés of the subject, one from its general and surgical aspects, by Graham (1), and the other from the pathological standpoint, by Olch (2). The ground, therefore, has been thoroughly covered and there is now nothing new to be said. However, the publications on cholecystography, and discussion with other radiologists, lead me to believe that there is still enough misconception in regard to this test of the gall bladder to constitute an excuse for another addition to the already abundant literature dealing with it.

Our method of employing cholecystography, except as to the dye used, has remained essentially the same as when first published. The same statement applies to the criteria for interpretation of cholecystograms. Our preference is always for the intravenous use of the dye, which is administered early in the morning, with radiographic examination at 4, 8 and 24 hours thereafter. Patients without indication of the existence of a diseased gall bladder, who, in the course of a routine medical survey, are to have an examination of the gastro-intestinal tract, are occasionally given the test orally. The figures of the two methods will follow.

The use of sodium tetrabromphenolphthalein has long since been discarded for the more desirable substance, sodium tetraiodophenolphthalein. At the last meeting of this organization, Graham (3) presented a new dye for cholecystography, sodium phenoltetraiodophthalein, the isomer of the iodine compound formerly used. There are several advantages pertaining to it, and interpretation of cholecystograms made with this medium are to be slightly modified. This salt can be used in a smaller quantity (approximately a 2 to 3 ratio), is less toxic, and apparently concentrates to a greater density in the gall bladder. Its chief advantage, however, lies in the fact that it can be combined as a test of liver function at the same time that cholecystography is carried out. The variation of this isomer of sodium tetraiodophenolphthalein in cholecystographic behavior lies in prompter appearance of the image of the gall bladder, greater density, and a slight persistence of the shadow. The deviations, however, should not cause any difficulty in interpretation of cholecystograms made with it. The cost of the dye has been reduced to the point where we find it practical for use in everyday work. Up to a comparatively recent time its cost was prohibitive except for investigative purposes.

We have carried out cholecystography in 1,244 cases, 926 of them intravenously and 318 orally. It should be noted that the large number of oral cases does not represent our views on the desirability of this means of administration, but as a test of its worth. We have no hesitancy in pronouncing a gall bladder normal when it presents normal cholecystographic behavior following oral administration of the dye. However, we have not yet succeeded in bringing ourselves to the point of pronouncing a gall bladder pathological in those cases wherein there is deviation from normal after the dye is given orally. We have not obtained such brilliant results as those published by

[1]Read before the Twelfth Annual Meeting of the Radiological Society of North America, at Milawukee, Nov. 29–Dec. 4, 1926.

Stewart and Ryan (4). If we have a case with oral administration of the dye, with doubtful behavior of the gall bladder, we follow it with the intravenous test. Our total number of cases with sodium phenoltetraiodophthalein, which we are using exclusively at the present time, is: intravenous 257; oral 6; total 263. Our experience with it indicates that it is generally more satisfactory than any dye hitherto used. I infer from what I can learn from unpublished sources that there is a great preference among radiologists for the oral method of dye administration, which is in direct contrast with our own views.

Another point on which we deviate from the methods employed, apparently with great advantage, by other clinics and observers is in the omission of the fat meal. We have not considered that this is necessary for adequate performance of the test.

I hope you will pardon the repetition of a statement often made, both by my colleagues and myself, to the effect that cholecystography is a measure of one of the certainly known functions of the gall bladder, a test of its ability to concentrate the bile which enters it. This brings us to a brief consideration of some phases of the physiology of the gall bladder.

The question naturally arises, Why does the gall bladder concentrate the bile, and what is the mechanism by which it empties itself? The liver secretes bile continuously, whereas its discharge into the intestinal canal is intermittent and is determined by the presence of food or other substance in the duodenum. The total volume of bile secreted by the liver is great; that discharged into the intestine is far smaller. So it is necessary that this great bulk be reduced, and this is cared for by partial removal of its fluid elements. As to the mechanism at work in the discharge of the contents of the gall bladder, I subscribe to the view of Graham, Cole, Copher and Kodama (5), set forth in a recent publication. This, briefly, is that an important factor in the emptying of the gall bladder is elastic recoil, through its resiliency following duodenal relaxation brought about by the passage of food from the stomach. They suppose that, at rest, the intramural portion of the common duct is occluded by tonic contraction of the duodenum. With relaxation of the duodenal tone, liver bile flows into the duodenum and washes out that of the gall bladder, thereby forming an interchange between liver bile and gall-bladder bile. The fasting stomach is but a small narrow tube in a state of collapse, in all probability one of tonic contraction, as anyone realizes who has followed the ingress of the opaque meal into it. The presumption is that the duodenum at rest is in an identical state, and consequently the hypothesis of the writers mentioned as to a tonic contraction of the duodenum shutting off the flow of bile into the intestine seems correct. It is certainly true that, so far, no one has been able to determine exactly the state of either the stomach or the duodenum when at rest. The musculature of the gall bladder is of such delicate development that it must surely have only the function of adjustment of the organ to its contents, rather than propulsion. Those interested in the subject should carefully study the work of the investigators alluded to.

Holding to the view, then, that the emptying of the gall bladder is passive and due to its resiliency, we do not consider that it is necessary to administer the fat meal to determine alterations in size of the dye-filled organ and to establish the flexibility of its walls. If the gall bladder be visualized, it is *per se* strong evidence of the integrity of its walls. A pathologic process causing inflammation and rigidity, as the subject has been studied in this clinic, indicates that such an organ is devoid of concentrating ability. It is for the same reason that only in the rarest

of instances do we attach importance to angular and rectilinear outline of the gall bladder when visualized in the cholecystogram. If the dye enters the gall bladder and is there concentrated, it seems preferable, for diagnostic reasons, to permit it to discharge itself under as nearly natural conditions as relative starvation will permit. The simplest possible methods of efficiently employing cholecystography are the ones that should be preferred. Recognizing the importance of the splendid work of Whitaker (6), Boyden (7), and, clinically, James T. Case (8), on the use of the fat meal, we still do not consider that it is essential for the proper carrying out of cholecystography.

The errors that have occurred in the use of this test appear to me to have arisen largely through excess of ingenuity in interpretation of the cholecystograms and without full appreciation of the importance of the concentrating function of the gall bladder. There has been too much tendency to use the test to discover deformities, stones, or other organic conditions, when it should have been regarded as a measure of the concentrating capacity of the organ. In our clinic we began with similar ideas and have gradually come to discard them in large part. We feel that disease of the gall bladder constantly and early impairs concentration, and that organic findings, when observed, are late, and a diagnosis of a pathologic state of the gall bladder should be made before they arise, if possible.

The writer feels now that in former publications he has leaned too strongly to the belief that cholecystitis is solely of bacteriologic origin (9). Cholecystitis probably also occurs through some chemical cause, associated, perhaps, with cholesterol metabolism. As a resultant, there is deposition of this substance on and in the mucosa of the gall bladder, and the formation of cholesterol stones, the second being but a later development of the first. A sterile inflamed organ may not cause symptoms, but it would certainly be liable to later bacterial invasion. Operative material in patients with slight symptoms, but with a pathologic cholecystogram, has revealed such a type of cholecystitis. This pre-infective, pre-lithiasis period is the time for the treatment of cholecystitis. It can be determined by cholecystography. The objection has been urged against cholecystography that in just such a period in cholecystitis, unassociated with bacterial invasion, is when it fails. The most notable objector to the method on these grounds is Richter (10), who states, among other things, that cholecystography tends to lead to consideration of disease of the gall bladder in terms of its late phases only, and further, in the face of normal cholecystographic behavior, to direct attention away from a diseased gall bladder. Our material indicates that the greatest value of cholecystography is in the early obscure case of disease of the organ. We do not believe that a pathologic gall bladder can produce a normal cholecystogram if the procedure is correctly carried out.

There is a type of gall bladder to which the term "atonic" is applied. This is a rather large pendulous organ, with otherwise normal cholecystographic behavior. A patient with such an organ has symptoms of digestive disturbance. If the supposition that the gall bladder empties itself passively through its own resiliency be correct, it naturally follows that there cannot be such a thing as an atonic gall bladder, and the writer believes this to be the case. A patient with such a gall bladder will show a slow alimentary motility and other deviations from what may be considered normal, all of which are slight in degree. The only case in which pathologic material was available bearing on this point was one whose cholecystograms had been displayed as a normal gall bladder, with both the oral and intravenous administration of the dye. The pa-

tient's digestive symptoms persisted, and reluctantly I decided that the clinician was correct in his opinion that there existed a cholecystitis even with a normal cholecystogram. Cholecystectomy was therefore carried out and an externally normal appearing gall bladder removed, which likewise appeared normal on incision. There was no evidence of pathologic change on microscopic examination. It is interesting to note that when this patient was last heard from there was persistence of those symptoms which originally brought him to the clinic. In this connection it must be stated that the weakness of estimating the value of cholecystography lies in the fact that those cases showing normal behavior with this test never have the gall bladder removed. Our own material has shown, however, that the symptoms could be ascribed to some other location than the gall bladder.

The radiologist called upon to aid in the diagnosis of disease of the biliary tract is frequently so much engrossed with demonstrating organic changes that he overlooks the fundamental condition, which is cholecystitis. His criteria of disease of the gall bladder are certain deviations of behavior of the ingested opaque meal supposed to be of reflex origin (and which may be a reflex of a diseased appendix, for example, and not a gall bladder), and certain anatomical changes. These have been dealt with in a previous publication (11), but I wish to restate them, since cholecystitis may exist without any of these signs being elicited. These are, in the order of their importance, the demonstration of stones, a thickened gall bladder, fixation of duodenum, stomach or intestinal loops, impressions on the duodenum and antrum pylori. Only about 50 per cent of our cases of cholecystitis have stones. Of these, there is an appreciable percentage (which is not ascertainable) of pure cholesterol type, having a specific gravity approximating the mean for that of gall-bladder bile. It is unreasonable to suppose that such a stone could ever have been demonstrated before the discovery of cholecystography, since the medium in which it is situated has approximately its own density. Cholecystitis may exist without material thickening of the gall-bladder walls, and if the latter are thickened sufficiently so that one is warranted in stating, on radiographic examination, that there exists a pathologic gall bladder, then it is a late finding and is *per se* a condition which it would be desirable to eliminate by an early diagnosis, for the reason that extensive damage has probably accompanied this change. Fixation of the structures about the gall bladder, without visualization of that organ, is nothing more nor less than evidence of the formation of adhesions from an antecedent localized peritonitis, an occurrence which should be prevented if possible. Antral and duodenal impressions as a sign of cholecystitis presuppose that shifting of the gall bladder is evidence of its disease. This is unreasonable in view of the wide normal range of position of that organ. We have shown these signs in normal cases (12). There is no intention to decry the brilliant work of those men who have done so much in the radiological diagnosis of disease of the gall bladder, and an examination to determine the existence of those changes should always precede cholecystography. Nevertheless, the matter may be summed up by stating that cholecystography gives an early and more accurate diagnosis, whereas ordinary radiographic methods reveal only late findings.

In this connection it may be mentioned that as experience has grown we have found that certain cases of deformity of the bulb, formerly going under the diagnosis of duodenal ulcer, have been found on cholecystographic examination to be deformities due to adhesion of an inflamed gall bladder. A review of these leads to the belief that in a

certain number the line cannot be drawn between deformity of the duodenal bulb from intrinsic and extrinsic causes, and that when such duodenal deformity is observed cholecystography should invariably be carried out.

In our clinic at the present time sodium phenoltetraiodophthalein is the substance of choice for use in cholecystography, for the reasons that have been advanced above. As experience develops, the possibilities are that its use will give further knowledge, not only of the gall bladder, but of the liver in various conditions. In all, some 43 substances have been used for cholecystography, but only about 4 of that number can be conveniently employed on the human subject, though many are excreted by the liver into the bile and concentrated by the gall bladder. Our recommendation would be for the employment of the salt in current use at the Barnes Hospital.

Up to October 9, 1926, of the 1,244 cases of cholecystography, 470 have been considered pathologic, 54 questionably pathologic, and the remainder normal. Of these 524 pathological cases, 147 have had the gall bladder removed and 143 have indicated a correct pre-operative opinion. This gives a percentage of 97.28 correctness in cases in which the gall bladder was studied after its removal. Percentages, however, mean little unless conditions under which they are made are known. If one culls the symptoms of the patients carefully before carrying out cholecystography, he should be able to be practically 100 per cent correct. Our early material contained some few cases in which cholecystography would nowadays be omitted, but taken generally, after the establishment of a little experience, the procedure was done only on patients in whom the diagnosis was not at all clear on clinical or other laboratory grounds.

It is in the case with obscure symptoms in the alimentary tract that cholecystography finds its most important use, for the reason that inflammation of the gall bladder early impairs or does away with its concentrating function, and such an organ should be dealt with in order that stone formation, thickened gall bladder, fibrous gall bladder and fixation may be prevented. Once the last two named have taken place, complete restoration to health of the person so affected is unlikely to take place.

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A NEW IODINE COMPOUND FOR CHOLECYSTOGRAPHY[1]

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THE extensive use of sodium tetrabromphenolphthalein and sodium tetraiodophenolphthalein in cholecystography, since they were first introduced by Graham and his associates, has shown that these two compounds will serve efficiently. Intravenous administration of these drugs for cholecystography has the advantage of assuring that a specified dose has been introduced into the circulation, and thus obviates all question concerning absorption through the intestinal wall. Menees and Robinson, in 1925, showed that the bromine salt could be given effectively by mouth, and shortly afterward Whitaker began to administer the iodine salt orally. The oral method is generally deemed safer from severe reactions, more facile of application, and hence more practicable. This is especially true where large numbers of patients are to be examined daily. Excellent results have been obtained at the Mayo Clinic through the oral use of the sodium salt of tetrabromphenolphthalein. However, the occasional reactions from the oral method, such as nausea, vomiting and purging, which may follow the administration of either of the salts commonly employed, are not only annoying to the patient, but in many instances cast doubt on the validity of the findings. To overcome these objections numerous methods of administering the bromine and iodine salts have been devised, only to raise new difficulties, for keratinized capsules and enteric-coated pills sometimes fail to dissolve. It would seem, therefore, that the problem has two principal aspects: (1) that of avoiding nausea, vomiting, and purging, and (2) that of facilitating absorption of the drug. Although it may be possible that these ends can be attained eventually with the salts now in use, the synthesis of a new salt may be an easier way. Accordingly, we set about to prepare a compound which would be free from disagreeable effects and which could be given in liquid form.

Tetrabromphenolphthalein and tetraiodophenolphthalein are insoluble except in the form of their sodium salts. When the sodium salts are given by mouth the nausea and vomiting which result in a varying percentage of patients are undoubtedly due to the high alkalinity of the salt. Neither tetrabromphenolphthalein nor tetraiodophenolphthalein contains an acid group, except after boiling in strong alkali. The sodium salt of these compounds is not a salt of an organic carboxyl, but is a phenolate, and in the presence of water the phenolate is immediately hydrolyzed to the free hydroxyl group and sodium hydroxide. The sodium hydroxide which is formed is probably more responsible for the toxic effect of the compound than is the tetraiodophenolphthalein itself. It also seems highly probable that the cause for the irritation in the intestines is the sodium hydroxide formed by hydrolysis of the phenolate. Since it is impossible to prepare a sodium salt of these compounds which is neutral in water, the effect of the sodium hydroxide must always be reckoned with.

In an attempt to find another substance which would not have such an alkaline reaction, di-iodo-ox-indol propionic acid was tried as a possible substitute for tetraiodophenolphthalein. It was then found that although the molecular weight of this compound was more than 500, and although it was given by mouth, it was almost completely absorbed and was excreted in the urine to the extent of from 80 to 90 per cent of the amount administered. Its absorption

[1]Read before the Radiological Society of North America, at Milwaukee, Wisconsin, November 29 to December 4, 1926.

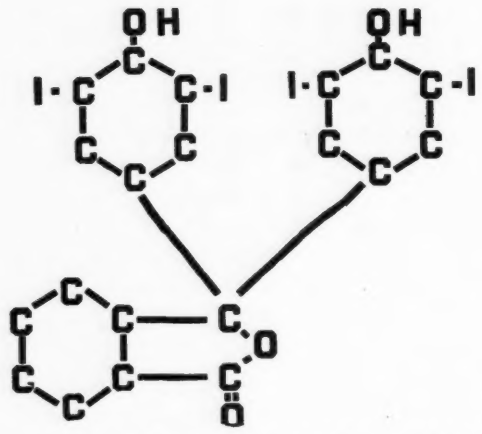

Fig. 1. Graphic formula of tetraiodophenolphthalein.

and prompt excretion suggested that probably some compound could be prepared which would be equally well absorbed and would be excreted in the bile. The acid group in di-iodo-ox-indol propionic acid is sufficiently strong to form a neutral salt with sodium; it therefore seemed probable that if acid groups could be attached to phenolphthalein the sodium salt of the iodine derivatives of this compound would be more easily absorbed and would not cause the disturbance brought about by hydrolysis of the sodium with the formation of sodium hydroxide. Di-salicylphthalein was therefore prepared and its di-iodo derivative was made. This compound resembled tetraiodophenolphthalein in color, but it was more soluble, was found to be far more toxic, and its objectionable taste excluded it from consideration.

There was at least one more change which could be made in this compound which theoretically should remove some of the objections. This change consisted in a substitution of the hydroxyl groups. The di-ethyl-ether of the di-salicylphthalein derivative was therefore prepared, and it was then found that the di-iodo derivative of this compound was an entirely colorless substance, the sodium salt of which was easily soluble in water and had a neutral reaction.

Di-iodo-di-ethyl-ether of di-salicylphthalein is a white crystalline powder. A 10 per cent aqueous solution of its sodium salt, the form in which it is now being given, is clear, colorless and odorless, and slightly bitter-

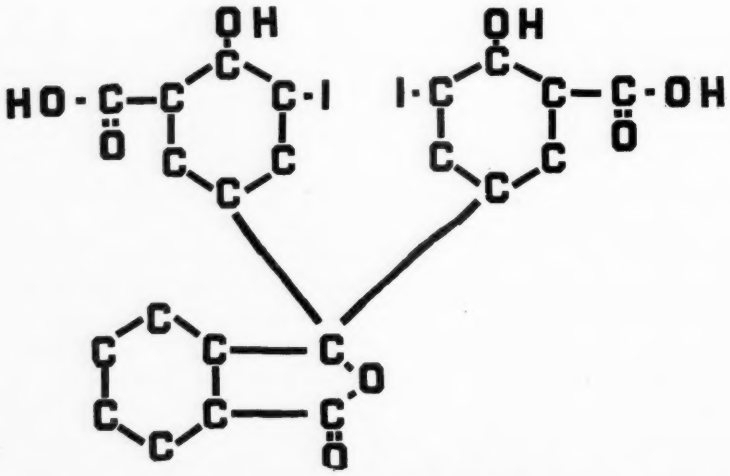

Fig. 2. Di-iodo-di-salicylphthalein.

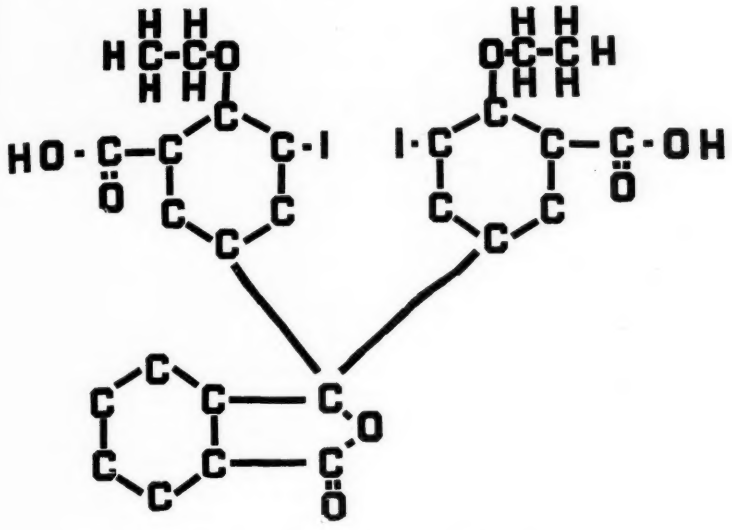

Fig. 3. Di-iodo-di-ethyl-ether of di-salicylphthalein.

sweet in taste, with a transitory warmth as of peppermint, which is not objectionable.

When given to dogs in doses up to 10 gm., the compound produced no toxic manifestations whatever. It was then given in varying, but small, doses to several patients who had been examined previously with the bromine salt and had responded normally to the test. In each instance the compound produced a visible shadow of the gall bladder. When the dose was increased to 7.5 or 10 gm., an excellent shadow of the gall bladder, denser than that produced in the same patient by the bromine salt, was secured. Practically no shadow of the compound in the bowel was observed; this would indicate that the drug is completely absorbed. Shadows of tetraiodophenolphthalein or tetrabromphenolphthalein in the bowel are seen often.

The technic of examination has not been essentially different from that followed with the salts commonly used. A bottle containing 10 gm. of the compound dissolved in 100 c.c. of water is given to the patient, and he is directed to drink the contents after an evening meal, free from fats. Breakfast is omitted and films are made at the fourteenth, sixteenth and twentieth hours. After the sixteen-hour film the patient eats a meal rich in cream, butter, or other fats. Other than a greater density of the shadow of the gall bladder and an absence of intestinal shadows, the reponse to the test seems to be identical with that resulting from the other salts.

Up to the present time, thirty-five patients have been examined after the oral administration of this compound. All the patients except one had previously been examined following the oral administration of the sodium salt of tetrabromphenolphthalein; in thirty-one of these the response had been normal. In each case, following the administration of the new compound, a normal shadow of better density was obtained. In the case in which the bromine salt had not been given previously the response was normal. In two cases transparent areas, evidently due to gallstones, were visible within the shadow of the gall bladder. Neither of these patients has been operated on. In a

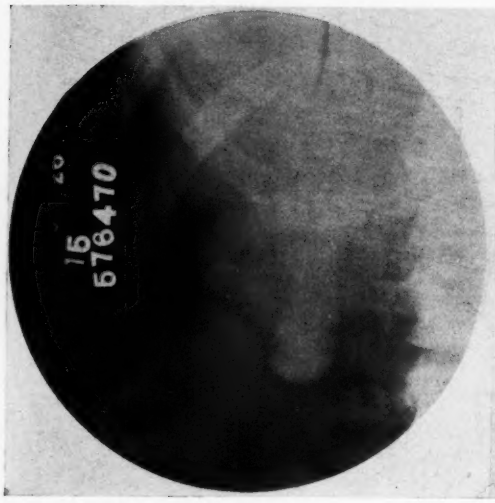

Fig. 4. Normal cholecystogram following oral administration of di-iodo-di-ethyl-ether of di-salicylphthalein.

Fig. 5. Cholecystogram after oral administration of di-iodo-di-ethyl-ether of di-salicylphthalein. Transparencies in shadow due to gallstones.

third case the gall-bladder shadow was faint, and definite disease of the organ was found at operation. This patient had been previously submitted to two examinations after administration of the sodium salt of tetrabromphenolphthalein and the gall bladder failed to cast a shadow at either.

None of the patients vomited the new compound, although several had vomited after taking the tetrabromphenolphthalein. Two patients were purged unpleasantly by the drug; one of these had recently had diarrhea and the bowel was still irritable. A few patients experienced a slight laxative effect, but without diarrhea or discomfort. We feel sure that this was caused by impurities in this particular lot of the drug rather than by the compound itself, as other lots failed to produce any untoward reaction. No patient had any other general ill effects, and all agreed that they preferred the new compound to the old with the unpleasant reactions which they had experienced with it.

Trials with the new compound are obviously too few as yet to sustain any definite conclusions. However, it is believed that the results thus far warrant this preliminary report. Experiments will be continued and their results will be announced later (Figs. 4 and 5).

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THE RATIONALE OF GALL-BLADDER DIAGNOSIS[1]

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THE subject of this paper is intentionally broad in scope because it is the writer's purpose, not to discuss a single phase of the problem, but rather to consider the relative and combined merits of various procedures tending toward accuracy in gall-bladder diagnosis.

The splendid contributions of Graham, Cole, and Copher (3, 4, 5, 6) have opened another door to rich opportunity for the radiologist, but they have also greatly increased his responsibility as a consultant in medical diagnosis. As experience accumulates, it becomes increasingly apparent that this method cannot be regarded as a laboratory test, with a specific reaction in every case of gall-bladder disease. In other words, it is not a procedure which can stand alone as a means by which to differentiate the pathological gall bladder from the normal.

As an aid to diagnosis, the artificial visualization of the normal gall bladder is of tremendous value, and this value will inevitably increase with experience. But if the radiologist is to meet his new responsibilities effectively, he must attempt to correlate his observations under this procedure with those derived from other diagnostic methods.

Before the X-ray era, the recognition of biliary disease depended largely upon subjective symptoms. Jaundice and the tender point under the margin of the liver were the essential objective findings. It is true that many cases masqueraded under such diagnoses as "nervous indigestion" and "hyperchlorhydria," but the typical case of biliary colic was a well defined entity.

Among the first radiologists to report consistent percentages of radiographically proven gallstone cases were Case (2), A. W. George, L. G. Cole (1), and G. E. Pfahler, but it remained for George to demonstrate the thickened gall bladder and to base diagnoses upon that finding. George's hypothesis rested upon a sound pathologico-radiological basis, but was discredited in many quarters by unsound criticism. It is true that direct visualization is subject to the error of mistaken interpretation. It is true that all pathological gall bladders are not thickened and that all thickened gall bladders may not be readily differentiated from other densities. It is probably not true that the outline of the normal gall bladder was ever clearly defined in any roentgenogram. That which was thought to be gall bladder was some extraneous density, and this differentiation can often be made with the help of the Graham-Cole procedure.

We have found this combined and coordinated employment of the old and the new to be of deciding value in many cases. The guiding principles and steps of the combined examination are the following:

1. Preliminary films are made without dye.

2. Subsequent films following dye administration may prove a suspected area of density to be (*a*) not the gall bladder, or (*b*) a gall bladder into which the phenolphthalein salt is excreted and which empties in a normal manner. Or the dye may not be excreted into the gall bladder; this negative observation is accepted as conclusive evidence, irrespective of findings in the preliminary films. If, on the other hand, the gall bladder is actually well defined in the preliminary films, this evidence is accepted

[1]Read before the Twelfth Annual Meeting of the Radiological Society of North America, at Milwaukee, Nov. 29–Dec. 4, 1926.

as positive, despite the normal excretion of the dye.

The most valuable sign of biliary pathology is the non-visualization of the gall bladder after the administration of the dye, but this evidence is greatly strengthened when the gall bladder can be outlined without dye.

Diagnoses based upon non-visualization after dye have proven correct in 79 out of 84 (94 per cent) cases operated on. Five cases were reported normal by the surgeon and in none of these had suspected densities been reported in the preliminary films. Evidence of pathological thickening or stones was reported in 41 (52 per cent) of this series.

The writer's experience seems to indicate that *reduction in size* of the dye-filled gall bladder is the best evidence of normality. A *decrease in density* following fat ingestion, without reduction in size, strongly suggests but does not prove disease. Mere *filling and emptying* does not prove normality, since we occasionally find such gall bladders thickened and filled with stones.

Irregularity of outline is rarely observed, but has proven a sound basis for a positive diagnosis in a few cases. In one of these the gall bladder was X-ray negative in all other respects but was found at operation to be firmly adherent to the duodenum and mesentery.

Emptying time has been found a variable and unreliable criterion of biliary pathology. This is especially true if the salt is given by mouth, since the time of absorption from the intestinal tract is a variable factor.

The degree of density of the dye-filled organ is, in the light of our present experience, of doubtful diagnostic value. Although it may vary in direct ratio to the concentration of bile by the gall bladder, it is nevertheless subject to variations in technic and interpretation which make it a questionable index of pathology.

The detection of stones, especially those of negative density, is an outstanding achievement of the Graham method. These are occasionally found in gall bladders which fill and empty with the excreted phthalein salt in a normal manner. Symptoms must be relied upon to determine their clinical importance.

The radiologist should bear in mind the fact that the gall bladder is only a part of the biliary tract and that pathological processes may involve the biliary ducts of the liver to such an extent that the dye may not be excreted, even though the gall bladder itself is relatively normal. That gall-bladder diagnosis cannot be reduced to any simple formula becomes quickly apparent when we consider the variety of pathological aberrations of chronic cholecystitis. Thus, a gall bladder may be (1) shrunken under the margin of the liver, with thickened, fibrous walls and a cavity scarcely to be recognized; (2) thickened, with a cavity containing only viscid mucus; (3) slightly thickened and adherent, with opaque white walls but with normal bile entering the bladder as a reservoir, or (4) extremely thin, like parchment, and not functioning. There are multiple gradations between these extremes and it is possible to find a gall bladder microscopically normal, functionally normal, but containing stones and having a wall infiltrated with lymphocytes. The presence of stones should always be accepted as evidence of pathology, even though not *per se* an indication for operation.

Judd reports good operative results in many cases which showed no gross pathology at the time of operation. When the history is that of colicky attacks operative results are much better than when there have been only digestive disturbances associated with "discomfort."

The Graham-Cole-Copher procedure, insofar as it measures the functional capacity

of the gall bladder, may serve to differentiate these cases.

Simple cholangitis or hepatitis, apparently unassociated with cholecystitis, seems to modify or even prevent the excretion of dye into the gall bladder. Hence, one should interpret insufficient density of the gall-bladder shadow as evidence of biliary disease but not necessarily of gall-bladder pathology.

The fact that the direct visualization of the thickened gall bladder did not achieve more general recognition was due rather to the difficulties of technic and interpretation than to any weakness inherent in the method. When its use is combined with that of the Graham procedure the danger of false interpretation is removed, and many mistaken diagnoses may thus be avoided. A conclusive differentiation of questionable areas of density in the upper right quadrant is possible through the Graham procedure. It is even conceivable that a pathologically thickened gall bladder may function quite normally between attacks, when not actively inflamed. Such a case might prove Graham-negative at one examination and Graham-positive at another. Here the George method might serve to avoid the error.

As to the technic of artificial visualization, there seems no good reason to question the superiority of the intravenous to the oral method. Expediency seems to be the sole argument in favor of the latter. There is always an element of uncertainty as to the quantity of the salt which actually reaches the blood stream, and this throws doubt upon any diagnosis based upon non-visualized or faintly visualized gall bladders.

The following case reports illustrate the advantage of the combined method of examination over any single procedure.

CASE 1. Mrs. W. H. G. was referred to the X-ray department of Miller Hospital Clinic with a history of vomiting, loss of weight, epigastric distress usually about three hours after meals, and questionable food relief. There was also a vague history of slight periodical jaundice.

Radiological Examination.—In the preliminary films there appeared a circumscribed area of slightly increased density to the right of the spine in the plane of the second and third lumbar vertebræ. Twelve hours after the oral administration of tetraiodophenolphthalein the density of the above-described area was definitely increased, proving it to be due to the gall bladder. At this time a faintly outlined negative shadow could be discerned.

Operation by Dr. John T. Rogers.—Cholecystectomy.

Pathological Report by Dr. Warwick.—"The gall bladder is enlarged to a slight degree. On cross-section the wall appears moderately thickened and edematous. The mucosa shows veining with yellow lines. In the lumen there is a large translucent stone with slightly nodular surface.

"Microscopically the mucosa is normal but throughout the thickened wall is a very rich infiltration with lymphocytes and pus cells. Blood vessels markedly congested."

CASE 2. Mrs. B. gave a history of epigastric distress after meals, with comparative comfort when on a strict diet. Analysis of gastric contents showed hyperacidity.

Radiological Examination.—The barium meal observations were negative. Preliminary gall-bladder films revealed a large circumscribed area of slightly increased density in the gall-bladder region. After dye administration this density was greatly increased, proving it to be due in fact to the gall bladder. Three hours after fat ingestion this area had reverted to its original density. Conclusions were indeterminate since, according to the Graham test, the gall bladder might be normal.

Operation.—Cholecystectomy, June 24, 1926, by Dr. J. T. Rogers.

Pathological Report.—The gall bladder is enlarged slightly. The wall is moderately thickened and edematous. The mucosa is veined with raised yellow lines. In the lumen are several small stones, 3 mm. in diameter, composed of soft yellow salts.

Microscopically the wall was infiltrated with lymphocytes and occasional pus cells.

It must be borne in mind that the above cases are selected from a large number to illustrate and emphasize a single point, *i.e.*, the value of the combined examination and the necessity of correlating all X-ray findings with clinical evidence to arrive at ultimate conclusions.

A much larger number of cases might be selected in which correct diagnoses were based exclusively upon the results of the Graham-Cole-Copher procedure.

CONCLUSIONS

The artificial visualization of the normal gall bladder has materially increased the accuracy of biliary diagnosis.

It remains necessary, however, to depend upon direct visualization in certain cases.

Collaboration with internist and surgeon will tend to prevent diagnostic errors both of omission and commission.

The radiologist, if he is to exercise his functions effectively in this important field, must bear in mind that the diagnosis of chronic biliary disease is not always an indication for operation.

Many of these cases present only symptoms of disturbed digestion without colicky attacks and such cases are often not benefited by operation. They may improve under careful management and it is to be anticipated that subsequent radiological examinations will reveal objective evidence of such improvement.

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ORAL CHOLECYSTOGRAPHY: COMPARISON OF METHODS[1]

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AS there is no standardized technic in oral cholecystography, a comparative series was attempted to determine the relative value of several methods. One hundred patients were given sodium tetraiodophenolphthalein in Whitaker's stearic-acid-coated pills (1); one hundred formaldehyde-hardened capsules, and one hundred Oakman's salol-coated capsules (2). It was desired to try several other methods, but the time was insufficient.

All of these patients were clinically suspected of having diseased gall bladders, or had symptoms which made it desirable to exclude gall-bladder pathology. The majority of them were women and over thirty-five years of age.

The salol-coated capsules and formaldehyde capsules were given during the evening meal and the stearic-coated pills were begun about two hours after the meal. Oakman's capsules were given at the rate of five grains for each twenty pounds; Whitaker's pills at the rate of five grains for ten to twelve pounds, and the formaldehyde capsules, fifteen grains to twenty-five pounds. No alkali was given with Whitaker's method. Sodium bicarbonate was given with formaldehyde-hardened capsules, fifteen grains a quarter of an hour before the meal, and five grains with each capsule. Thirty grains of desiccated sodium carbonate were given in divided doses two hours after the salol capsules. The formaldehyde capsules were filled with dye without olive oil. No restriction was placed on the diet of those receiving the formaldehyde capsules. Light diet was given with Whitaker's and liquid with Oakman's. There was no preliminary purgation in any of these cases.

All were radiated the following morning without breakfast, about fifteen hours after the administration. They were then given a fat-rich meal. A second set of films was taken in two hours. Occasionally, later films were taken.

Table I shows the results of the three series. The salol-coated capsules showed the smallest number of failures to disintegrate and failures to outline the gall bladder, with the largest number of dense gall-bladder shadows. These advantages are more apparent, since they are obtained with the smallest dose. The small dose gave fewer conflicting shadows of dye in the colon.

Twenty-four of these cases have come to operation and one to autopsy. All were considered pathological and this was confirmed in all but one case. At operation, this case showed a carcinoma of the stomach and the gall bladder was not removed.

The superiority of the Oakman method is due probably to the use of sodium carbonate. This is a powerful enough alkali to form sodium tetraiodophenolphthalein from dye precipitated by hydrochloric acid and make it soluble and available for absorption. This can be readily shown in a test tube; while with sodium bicarbonate this does not happen and the precipitated dye remains white and insoluble. As another confirmation of this, gall-bladder shadows have been obtained after the administration of precipitated dye and sodium carbonate.

Table II shows the reactions in the three

[1]Read before the Radiological Society of North America, at the Twelfth Annual Meeting, at Milwaukee, Nov. 29–Dec. 4, 1926.

series. The salol-coated capsules gave the most frequent nausea and diarrhea, but the frequency of the vomiting was not increased. In many cases the nausea was slight and transient. The reason for this is not determined. There are three possibilities: irritation of the salicylic acid from the salol, from the sodium carbonate, or from the presence of more soluble dye in the bowel.

A comparison of the stearic-acid pill and hardened gelatin capsule was attempted by giving the same patient the two methods. When the interval between the two was only twenty-four hours, and a gall-bladder shadow was present, a majority showed an improvement in the quality of the shadow, irrespective of the method. In ten cases of Whitaker's method, followed by the hardened capsules, eight showed a definite improvement in the density of the shadow. In four where the Whitaker method followed the capsules, there was distinct improvement in three. One of these, which failed to show an outline on the first administration, showed a normal gall bladder following the second. Longer intervals than twenty-four hours showed only an occasional improvement. The second administration gave no increase in severity of symptoms.

This improvement can be accounted for best by an accumulation due to re-absorption of excreted dye. A portion of the first dose is still available, and is added to the second dose, giving a larger quantity of soluble dye. The interval between the doses should not be greater than twenty-four hours to obtain the maximum effect. The value of repeat doses has been emphasized by Ullmann and others. We have differed from Ullmann in not using compound licorice powder between the doses, fearing a flushing away of the first dose. Whitaker (1) relates an experience of Sosman's of finding a gall-bladder shadow on barium meal films, seventy-two hours after intravenous administration. This gall bladder was empty at twenty-four hours. They concluded that the dye must have been re-absorbed and re-excreted.

SUMMARY

1. The Oakman method gave the largest percentage of satisfactory gall-bladder shadows of the three methods investigated.

2. This is probably due to the use of sodium carbonate as the alkali. Sodium carbonate is a sufficiently powerful alkali to form the soluble sodium salt from insoluble tetraiodophenolphthalein. This makes dye precipitated by the hydrochloric acid of the stomach again available for absorption.

3. Sodium tetraiodophenolphthalein shows a cumulative action following repeated doses. This furnishes a rational basis for a repeated oral dose in gall bladders which do not fill or fill poorly. A normal gall bladder has less chance of failing to fill with the repeated dose, and the accuracy of the oral method is increased.

TABLE I

	Hardened gelatin capsules	Stearic-acid-coated pills	Salol-coated capsules
Failures to disintegrate	6	22	3
Gall bladder not outlined	23	10	6
Shadow faint	40	51	39
Shadow of fair density	21	21	24
Shadow of good density	16	18	31

TABLE II

	Hardened gelatin capsules	Stearic-acid-coated pills	Salol-coated capsules
Nausea	27	33	50
Vomiting	11	13	12
Diarrhea	3	5	22
Headache	21	12	17
Symptom-free	60	56	40

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DISCUSSION

Dr. William C. MacCarty (Rochester, Minn.): I presume I was picked to open this discussion because I have lived long enough to see the evolution of what we have been talking about in this symposium. It has been a privilege to watch the development of this subject, and I do not know of any subject I would rather discuss than the one we now present. I remember quite well in our clinic, our first roentgen-ray machine was operated by Dr. H. S. Plummer, then Dr. Willey, by Dr. Selby, and then of course came Dr. Carman. I remember also quite well that it was Dr. Carman who decided that it was absolutely necessary in our clinic, at least, for a close co-operation between surgeon, roentgenologist, and pathologist. Of course the pathologist had been closely related to the surgeon for a number of years, but when the three got together, then we began to make progress.

I am going to discuss the last paper first; these statements I have written down because they are the result of my observations in checking. Diagnosis and judgment of the roentgen-ray department are based upon 1,529 gastric cancers, 1,098 gastric ulcers, 579 duodenal ulcers which were excised and examined pathologically, 146 specimens of duodenums which were termed duodenitis and were excised with the expectation of finding possibly a duodenal ulcer. In dealing clinically with these conditions the roentgenologist is of greatest value; in many instances his study is the only method which gives a clear understanding of the exact location of a lesion, or whether or not a lesion is present.

In regard to cholecystography, it might be of interest to report a recent experience. For some time we have been checking our pathologic findings in the gall bladder with the roentgen-ray diagnosis. This study has two objects: first, to determine the efficiency of roentgen-ray diagnosis, and second, to find out whether definite gross structural change in the organ is necessary for failure of the organ to fill with dye according to the Graham-Cole method or a modification of it. In our studies of 276 gall bladders which had been examined by the roentgen ray it was found that in 229 a pathologic condition had been diagnosed. Of this number 202 (87.4 per cent) showed definite disease on pathologic examination; 27 (12.6 per cent) failed to show any grossly visible change. It must be remembered, however, that there may be no gross changes and still be histologic changes such as congestion and lymphocytic infiltration. The negative diagnoses of the roentgenologist are, however, not so encouraging, since among 47, 29 (61 per cent) were incorrect in that definite pathologic changes were found in the organ.

Perhaps this difficulty is to be expected because it is usually the difficult and indeterminate case which is referred for roentgenologic study. This may be clearer if we review the accuracy of clinical diagnosis of gall-bladder conditions without the aid of roentgenography. Thus, in a series of 182 gall bladders, disease was diagnosed before operation in 147. Of these, 91 per cent showed definite gross pathologic changes. The clinician, however, is in the habit of making 19 per cent of his gall-bladder diagnoses with the reservation that the pathologic condition may be in the appendix, duodenum, or stomach. In other words, we may expect approximately 19 per cent of patients with a suggestive history of chole-

cystitis not to give a perfectly clear history of gall-bladder disease; there may be many other conditions which either mask the condition or simulate it. As a rule it is just such questionable cases which the roentgenologists in the clinic are likely to see for diagnosis. If this be the case, their diagnostic efficiency is very good.

It seems to me that the only test of the Graham-Cole method or any modification of it rests on the actual findings after cholecystectomy; the clinical history and the gross external appearance of the organ should not be used to check the method. From these figures I would say that cholecystography is still in the experimental stage and that in general the clinical history and age of the patient are still our best guides to diagnosis. Cholecystography should still be considered an accessory diagnostic procedure with possibilities of improvement. A suggestive history of gall-bladder disease with positive roentgenologic findings might warrant exploration, but positive roentgenologic findings without a suggestive history would not, in my opinion, necessarily warrant exploration and cholecystectomy.

It is possible that we may later determine that there are functional disturbances of this organ which relate to failure in filling with the dye. Therefore, I believe that investigative cholecystograms should be continued.

I have great faith in Dr. Graham and Dr. Moore, and if they say a thing is so, I am apt to think it is so; in other words, we must keep open minds and must not forget to check our roentgen examination and diagnosis by actual exploration and examination of the specimen. I believe that, like the use of the roentgen ray in other portions of the body, cholecystography must always be used in conjunction with the clinical history and other physical examinations. It is not a thing to be relied upon alone, in my experience at any rate.

Dr. Robert A. Arens (Chicago): These papers have been of unusual interest to me, because I have been interested in the subject of cholecystic disease rather intensively for a number of years. I think the paper of Dr. Menees is well considered from the standpoint of the extensiveness and thoroughness with which he carried out his work with the various salts, as they are being put out to-day. Unfortunately salol always seems to give the best results from the standpoint of producing the best shadows but also produces the greatest amount of reaction. The work of Dr. Kirklin and Dr. Kendall certainly, in my opinion, seems to offer something for which we have been seeking for a long time. It seems to me very simple, very easy to give, and apparently non-injurious. I hope they will be able to carry their work out to a successful conclusion, and that in the very near future this salt will be made available to the profession at large.

One of the difficulties that we have been having with the dye method, especially the oral method, has been the presence of the dye in the intestines. Frequently we have found so many unbroken or undissolved capsules in the hepatic flexure that they have seriously interfered with the visualization of faint gall-bladder outlines. It is rather interesting at this meeting to feel that the older methods, or so-called primary film methods, have not been entirely discarded, that the straight field method is being used more and more, being checked up by the present dye method, and that, in many cases, the straight film method has been a check on the dye and the dye on the straight film method. I believe as time goes on we will find that both methods will take their proper levels. It seems to me that one of the difficulties of the tetraiodo method is not in the application of it by the radiolo-

gist, but in its misinterpretation by the medical profession at large, who frequently request a radiograph of the gall bladder by any method, preferably by the dye. They are not interested in the balance of the gastro-intestinal tract. I feel that we should devote every effort to making as complete a gastro-intestinal examination as possible, using every means at our command, rather than to permit the profession at large to use the dye method. I believe Dr. Bissell's points are well taken; they are conservative; he has covered the subject well, and one point he brings out—the matter of a change in the size of the gall bladder when filling or partially filled. I agree with him that the lack of density of the gall bladder is no criterion as to its being pathological. May I also make one point in regard to Dr. Sutherland's paper?[1] I feel that he has brought out a point which, while he brings it out specifically, does not say it in so many words. It is mainly this: that one must be extremely careful in what he calls a normal cap. The extreme care with which Dr. Sutherland rotates his patient and insists that the cap must be normal from all angles before it can be called a normal cap, is something that ought to be impressed upon the minds of us all. I have come to the point where I feel that I have great difficulty in determining what constitutes a normal cap. I am glad that Dr. Sutherland emphasized that point.

Dr. H. J. Ullmann (Santa Barbara, California): We have done considerable experimental work with the capsules. We even went to the extent of filling them with barium, and, after hardening them at different times and checking up their passage through the gastro-intestinal tract, we have come to feel that even a very small amount of hardening will result in a large proportion of them going entirely through the tract undissolved. Following Dr. A. B. Moore's suggestion, we tried the unhardened capsule and now use nothing else. We add one grain of sodium bicarbonate to each capsule and believe that it results in better absorption of the dye. We rarely see anything in the colon except a staining of the feces. We have had many cases in which the dye was absorbed but the gall bladder did not fill, although, when repeated by the intraveneous route, the gall bladder filled normally.

I was glad to hear the reference to Dr. Boyden's papers because I have found them of extreme interest. It is necessary to read them to obtain a thorough understanding of gall-bladder physiology.

Dr. M. C. Sosman (Boston): There are just three points I would like to bring to your attention. The first is the question of the fat meal which Dr. Moore mentioned. We have found that after the fat contraction, which should be 50 per cent in the first hour, we may visualize stones which are otherwise covered by the dense shadow of the dye. This has happened to us in four or five cases out of about a hundred and twenty cases showing stones; in other words, it is a very valuable help. However, if you get no contraction of the gall bladder after the fat meal, it is not necessarily an indication of thickening or of inelastic gall-bladder walls, because we have found also that if your patient is nauseated—if the fat does not pass the pylorus—you will not get contraction of the gall bladder.

The second point I want to make is the extreme value of this test in the study of the physiology of the gall bladder. Very excellent work has been done showing some things that have never been known before on the gall bladder, and I would like to recommend Boyden's paper in the *Anatomical Record* of August, 1926, as being an excellent summary of information and experiments to date. One thing of particular interest is the sort of film which he made,

[1] See Duodenal Ulcer: A Comparison of the Roentgenologic and Histologic Findings. C. G. Sutherland. Radiology, February, 1927, p. 111.

or which we made for him, more or less by Cole's serial radiography, showing the rate of contraction of the filled gall bladder and the various factors in this rate of contraction.

The final thing is that when we talk about percentages of accuracy we are barking up the wrong tree. That is said with all due respect to the pathologist, who is almost infallible, but every gall bladder removed will be reported as pathological. I think the real test of the success of the method should be the effect on the patient of the removal of the gall bladder diagnosed as non-functioning or as poorly functioning or as pathological, by cholecystography. In fact, the condition of the patient two or three years after that gall bladder has been removed is the most important criterion. In other words, we must consider the patient and not his or her gall bladder.

DR. KIRKLIN (closing): Several have asked me about the availability of this new salt. We have been able to get only enough of it to carry on a small series of experiments, so for that reason we feel we should try it out on a large number of patients, and then, if it is decided that it has advantages over the salts now commonly used, it will be placed on the market and will be available probably within two or three months.

DR. SHERWOOD MOORE (closing): I do not believe there is anything more to be said. I probably gave a wrong impression to Dr. MacCarty. My idea in saying that a gall bladder is or is not pathological is from an examination of it after excision, not otherwise, and I would like to endorse what Dr. Sosman says, that the merit of any treatment of the gall bladder is the condition of the patient after a sufficient lapse of time.

DR. C. G. SUTHERLAND (closing): I have nothing further to say[2] except that, of course, it is impossible for one to discuss thoroughly the diagnosis of duodenal ulcer in a limited time. There is one little point in connection with duodenal ulcer which Dr. Moore mentioned that is rather interesting in connection with checking up our diagnoses of duodenal ulcer with the surgical findings. We find that the most frequent of all the errors made are those in which duodenal ulcer has been diagnosed by a definite deformity of the duodenal cap having all the roentgenological appearance of duodenal ulcer but associated with cholecystic disease. That is, we do not find the duodenal ulcer at operation, and when we do not, we almost invariably find that the surgical report is cholecystic disease. If you can, by approximation of the anterior and posterior wall of the duodenum, demonstrate a niche, you can report duodenal ulcer with approximately 99 per cent accuracy. The last series that we had ran 99 per cent accurate, and there was some doubt about only one case in the series in which the surgeon did not find the ulcer.

2Dr. Sutherland's paper was published in RADIOLOGY, February, 1927, p. 111.

THE ANATOMY, PHYSIOLOGY, AND ANOMALIES OF THE SPINE[1]

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THE study of the normal chronologic changes of the human spine is of vital clinical importance to the roentgenologist. The manifestations of disease, such as proliferative and degenerative changes, must at times be differentiated from the results of normal processes. The same emphasis must be placed on congenital anomalies as is placed on chronologic changes. The importance of the knowledge of congenital anomalies has a legal bearing, especially in cases of injury. A correct evaluation of the roentgenologic findings is imperative where injury has brought the patient up for study. Many cases of congenital anomalies are found on routine examination, without a single clinical symptom. If an individual with a congenital anomaly such as spina bifida occulta, however, has a back injury, this malformation may be raised from minor to major clinical importance in the consideration of the differential diagnosis and from the aspect of medical jurisprudence.

ANATOMY OF SPINE

The human spinal column is normally composed of thirty-three segments, or vertebræ, twenty-four of which are true, or movable, and nine false, or fixed. Of the true vertebræ, the first seven are called *cervical*, the succeeding twelve, *thoracic*, or *dorsal*, and the remaining five, *lumbar*. Of the false vertebræ, the first five form one mass, called the *sacrum*, and at the terminal part of the column there are three to five fused segments forming the *coccyx*.

The vertebral column functions as a pillar of support for the trunk and a case for protection of the spinal cord and nerve roots and meninges. Cephalad it supports the skull; laterally it gives attachments to the ribs, through which, in part, it receives the weight of the upper limbs, and caudad it is supported by the hip bones, by which the weight of the trunk is transmitted to the lower limbs. The structure of the whole column accords with the necessities of these functions, and thus the vertebræ of which it is composed show their individual agreement with the general arrangement of the whole: they are modified in detail according to their position, but they are all built on the same general principle.

This principle may be illustrated briefly on a vertebra taken from the center of the column and used as an illustration of the positions of the chief parts of a typical vertebra. In front, a strong *body* carries and transmits weight. It is the more fixed part of the column and to its dorsal aspect is attached the spinal cord. The attachment of the spinal cord to the more stable bodies prevents overstretching of the cord in flexion of the column. The *neural arch* behind the bodies covers in the spinal cord: in conformity with this we find the strong pads of intervertebral discs placed between the bodies of contiguous vertebræ, whereas the arches are connected by ligaments and tend to overlap one another. The arch is relatively more movable than the body. In the articulated column the successive arches and ligaments, with the dorsal aspect of the bodies, enclose a spinal canal for the cord

[1]Read before the Twelfth Annual Meeting of the Radiological Society of North America, at Milwaukee, Wisconsin, Dec. 4, 1926.

and meninges (pachy- and leptomeninges), and the portion of the canal that is enclosed in the neural arch of each separate segment is the spinal foramen of that vertebra. The neural arch has spinous, articular, transverse processes, as well as laminæ and pedicles. No details of these structures are necessary in this paper.

The length of the spinal column varies in different skeletons, but on an average it measures about 70 cm. in the male and about 2.5 cm. less in the female. It constitutes about 45 per cent of the entire body length. To the entire length of the column the cervical region contributes about one-sixth, the thoracic about one-third, the lumbar about one-fourth, and the sacro-coccygeal portion the remainder. About one-fourth of the length of the pre-sacral spine is made up of intervertebral discs.

The length of the movable or free vertebral column (cervical, thoracic, and lumbar) at the end of the second fetal month is about 2 cm.; in the third fetal month 4 cm.; at the end of the fourth 8 cm., and at the end of the ninth fetal month 20 cm. Between birth and maturity the movable vertebral column increases in length about 2.5 times: two-thirds of this growth is reached before puberty.

The ratio of the various segments of the vertebral column shifts with the chronologic and anatomic age of the individual. The cervical and sacral regions form the greater part of the column during the second and third fetal months. At birth the cervical part forms approximately one-fourth, the thoracic part one-half, and the lumbar one-fourth of the movable vertebral column. By the third year the adult ratio is reached and this has been given above.

The striking characteristic of the complete articulated column when viewed as a whole is the presence of "curves." There are two sets of these—the primary or accommodation curves and the secondary or compensation curves. There are four of these in the sagittal plane, or profile view, convex forward in the cervical and lumbar regions, concave forward or ventrad in the dorsal and sacral zones. The dorsal curve is primary and may be looked on as the persisting curve of the embryonic axis. The sacral curve is also primary. These two primary curves are for the accommodation of the thoracic and pelvic viscera. The thoracic curve extends from the second to the twelfth dorsal vertebra, and the sacral curve coincides with the sacrum and the coccyx.

The secondary curves of compensation are found in the cervical and lumbar regions and have their convexities directed ventrad. They are curves that compensate for the assumption of the upright posture and are developed due to changes in the intervertebral discs. The cervical curve appears with the development of ventral flexion of the head on the chest at about the third post-natal month of the infant, and with the sitting posture at about the sixth post-natal month. The curve is never consolidated or fixed in the vertebral column. It is present in the upright, but obliterated in the horizontal posture.

The lumbar curve between the twelfth dorsal vertebra and promontory of the sacrum appears between the ninth and twelfth post-natal month, when the child begins to stand and attempts to walk. This curve becomes consolidated in adult life.

The most anterior part of the cervical convexity is the front of the body of the fourth cervical vertebra, and the curve ends below, about the second dorsal. The body of the seventh or eighth dorsal usually forms the point of greatest posterior projection in the dorsal curve, which ends below, between the twelfth dorsal and first lumbar vertebra.

The fifth curve is lateral and is a secondary, compensation curve. It is in most

cases directed to the right and is found in the upper thoracic, or dorsal, region. Its convexity, usually to the right, is probably associated with the greater use of the right hand. It is modified by race and occupation. The common finding in the ventro-dorsal view, therefore, is a physiologic right lateral scoliosis.

The primary curves of accommodation have associated direct changes in the bodies of the dorsal and sacral regions, whereas the secondary, or compensation, curves have associated changes particularly in the discs. At about the third week of intra-uterine life the first primary curve appears with the snail-like coiling of the entire embryo. During this time the vertebral column has a pronounced ventral flexion. The uncoiling of the embryo occurs between the third and sixth week of intra-uterine life. The movable, or free, portion of the vertebral column gradually becomes straighter, while the sacral portion first becomes straighter and later acquires a second ventral curve. In the newborn child the true, or free, column forms a single gentle curve with a ventral concavity extending from the first cervical to the last lumbar vertebra, while the sacrum and coccyx are directed somewhat dorsad.

In the female the sacrum is turned dorsad to a greater extent than in the male. This causes a more prominent lumbo-sacral angle, but it is modified by the lumbar curve becoming more pronounced: thus, in women the fourth lumbar is usually more prominent than in men. If an anomalous sixth lumbar vertebra is present there is consequently a still greater tendency to spondylolisthesis, a forward gliding of the caudal surface of the fifth lumbar over the cephalic aspect of the first sacral vertebra.

The presence of the primary and secondary curves in the column or vertebral pillar above the sacrum adds to its elasticity, while the number of curves gives it a greater resistance to weight than would be afforded by a single curve. Weight is transmitted to the top of the sacrum and from thence to the innominate bones, so that the sacral curve is merely an adaptation to the contents of the pelvis not concerned in weight transmission, and differs in the sexes.

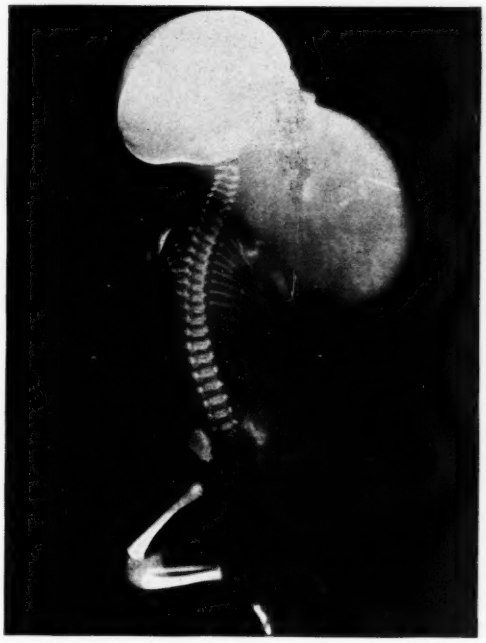

Fig. 1. Teratologic radiograph of asymmetrical duplicity. Fullterm. This parasite of the lower jaw and ventral aspect of neck and mouth (epignathus) is a tumor enveloped by skin, containing hair, sebaceous cysts, teeth, cartilage, and rudimentary ill-defined bones. Note the compensatory scoliosis in the right dorsal region of the spine. There is rotation of the bodies in the cervical and upper dorsal regions to the left.

The aortic impression consists of a variable flattening of the left side of the dorsal vertebræ from the fourth to the tenth segment.

From the ventral aspect the bodies of the vertebral column present a series of pyramids due to the successive increase and decrease in the size of the bodies. They become wider from the axis to the first dorsal

vertebra, then decrease to the fourth dorsal. The apex of the first pyramid is directed upward; of the second, its apex is directed downward. Their bases are in apposition. The third pyramid extends from the fourth superficial layers of the post-vertebral muscles.

Observe the spinous and transverse processes in the roentgenogram. The former project in the midline, and the latter as two

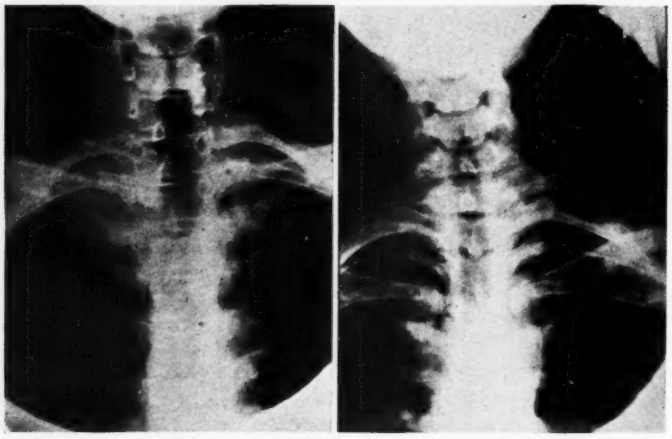

Fig. 2. The right figure has a left cervical rib three inches in length attached at its distal end to the left first rib. On the right side a rudimentary cervical rib one inch in length is present. The left figure has bilateral calcification of the vertebral arteries.

thoracic to the fifth lumbar vertebra, with its base caudad. The fourth pyramid includes the sacrum and coccyx, with the base cephalad and the apex caudad.

In the lateral view, the intervertebral foramina appear oval in shape. These foramina increase in size progressively from cephalocaudad, being smallest in the cervical, and largest—in diameter—in the lumbar region. The spinous processes of the second and seventh cervical, first thoracic and all the lumbar vertebræ are most prominent.

From the dorsal aspect the line of the spines has frequent irregularities without any deviation in the line of the weight bearing bodies. On each side of the line of the spines the vertebral groove runs down the length of the column, floored by the laminæ and backs of the articular and transverse processes: it is occupied by the deep and lateral rows. The width of the transverse processes varies. It is more or less regular in the cervical region, but great in the first and last members of the series: it decreases from above down in the dorsal vertebræ, and increases again in the lumbar to the third or fourth.

TOPOGRAPHIC ANATOMY

There are certain vertebræ which are of special value to the physician, since they stand as landmarks to guide him to the seat of other parts of the body. Thus, the third cervical vertebra corresponds to the following parts: (1) the opening of the larynx, (2) the bifurcation of the carotid artery, (3) the point of origin of both the external and internal carotid arteries, and (4) the situation of the superior cervical ganglion of the sympathetic nerve. The fifth cervical vertebra is a guide to the following

parts: (1) the lower opening of the larynx, (2) the beginning of the trachea, (3) the lower end of the pharynx, (4) the upper opening of the esophagus, and (5) the middle cervical ganglion of the sympathetic nerve. Finally, the second lumbar vertebra corresponds to the following parts: (1) the termination of the duodenum, (2) the commencement of the jejunum, (3) the lower border of the pancreas, (4) the upper root of the mesentery, (5) the point of origin of the superior mesenteric artery, (6) the commencement of the thoracic duct, (7) the opening of the ductus communis choledochus into the intestine, (8) the commencement of the vena porta, (9) the termination of the spinal cord, (10) the point of origin of the cauda equina, (11) the attachment of the crura of the diaphragm, and (12) the situation of the receptaculum chyli.

In addition to these three vertebræ, which are of special value as guides to more than one part of the body, may be mentioned—

(1) the *seventh cervical,* whose long spine is a guide to the level of the apices of the lungs in the male; in the female, it extends higher up;

(2) the *third dorsal,* at the level of which the aorta reaches the spinal column, the trachea bifurcates, and the apex of the lower lobe of the lung is found;

(3) the *eighth dorsal,* which indicates the lower level of the heart and that of the central tendon of the diaphragm;

(4) the *ninth dorsal,* at the level of which the upper edge of the spleen is found in health, and where also the esophagus and vena cava pass through the diaphragm;

(5) the *tenth dorsal,* which corresponds to the lower edge of the lung, the spot where the liver comes to the surface posteriorly, and the situation of the cardiac orifice of the stomach;

(6) the *eleventh dorsal,* guiding the student to the normal situation of the lower border of the spleen and to the upper part of the kidney;

(7) the *twelfth dorsal,* which marks the lower limit of the pleura, the passage of the aorta through the diaphragm, and the situation of the pyloric end of the stomach;

(8) the *first lumbar,* where the renal arteries are given off, and where the pelvis of the kidney may be found;

(9) the *third lumbar,* which corresponds to the level of the umbilicus, and the lower border of the kidney;

(10) the *fourth lumbar,* which marks the point of bifurcation of the abdominal aorta into the two common iliac arteries, and the level of the highest part of the ilium.

It may be of value to the physician in examining the chest or endeavoring to locate the exact situation of any particular point upon the chest, to remember that the spine of the third dorsal vertebra is on the same level as the commencement of the spine of the scapula; that the spine of the seventh dorsal vertebra lies on a level with the inferior angle of that bone; and, finally, that the spine of the last dorsal vertebra is on a level with the head of the last rib, which may be used as a guide in certain surgical operations upon some of the abdominal viscera.

Between the different vertebræ are placed foramina through which the spinal nerves escape from the spinal canal to reach the parts which each is destined to supply. It is often useful to know the vertebræ opposite to which the nerves of any special region arise from the spinal cord, since the point of origin does not always correspond to the foramen of escape. The following guides may be furnished by the vertebræ, to locate the seat of lesions of the spinal cord which are affecting any special nerve or set of nerves.

The interval between the occiput (inion)

and the sixth cervical spine marks the limits of origin of the eight cervical nerves; that between the sixth cervical and the fourth dorsal spine marks the origin of the first six dorsal nerves. Between the eleventh and twelfth dorsal spines the five lumbar nerves arise as the upper part of the cauda equina, while the origin of the five sacral nerves corresponds to the single vertebra, the twelfth dorsal spine. It should be remembered that the spines of the vertebræ are not always in a precisely straight line but that in persons possessing the greatest strength an occasional deviation of a single vertebra either to the right or to the left may exist. It is by knowing these natural defects that we can guard ourselves against error in diagnosis.

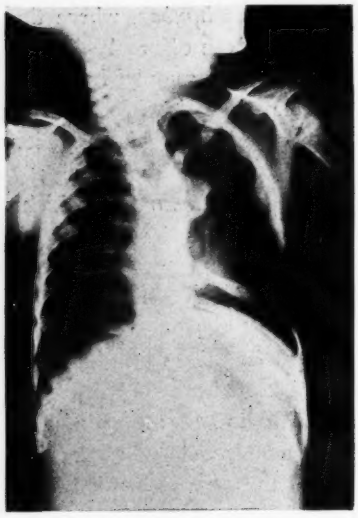

Fig. 3. Congenital scoliosis due to asymmetric development of ribs. The left fourth and fifth ribs are fused; there is absence of the sixth, seventh, and eighth left ribs. The left lateral scoliosis is most marked at the fifth thoracic vertebral level. There are compensatory curves to the right, above and below the anomaly of the spine in the dorsal region.

PHYSIOLOGY OF THE SPINE

The curves of the vertebral column serve the following purposes:

1. They contribute to the wonderful strength of the spine, sixteen times that of a straight one, since its curves are alternating.

2. They convert the spine into an elastic structure and thus afford a springy pillar upon which the head shall rest, reducing to a minimum the danger of severe jarring of the brain.

3. The curves are so arranged as to favor the lodgment of organs, since the cavity of the chest is greatly enlarged thereby. Also, the weight of these organs is still kept within the line of the center of gravity, a fact to be considered in the arrangement of muscles, as less power is required thereby to preserve the proper balance.

4. The curves are so gradual as to prevent the possibility of compression of the spinal cord, which might occur were there any abrupt angles to the canal.

5. The curve of the cervical and dorsal regions adds greatly to the beauty of outline of the body, while the cervical curve facilitates the movements of the neck.

The curves of the vertebral column are due, in great measure, to the variations in thickness of the intervertebral fibrocartilages, but partly also to the relative thickness of the bodies of the vertebræ of the different regions, and to the tension exerted by the ligamenta subflava, which connect the laminæ of the different vertebræ together.

The spinal column is capable of any one of four movements, *viz.*, flexion, extension, lateral movement, and torsion. The first two are most free in the neck, least free in the dorsal region, and less free in the loins than in the neck. This is largely due to the fact that the spines of the dorsal vertebræ

overlap each other, particularly from the fourth to the eighth, and that the articular processes of the dorsal vertebræ are nearly perpendicular, so that movement is prevented. Also, in the cervical region, the articular processes are oblique, the intervertebral discs thick, and the spinous processes of the third, fourth and fifth are purposely made short and horizontal. The lumbar vertebræ also have thick intervertebral discs, which fact allows of movement between their spinous processes; likewise, the articular processes are so placed as to allow of a limited movement. Flexion and extension of the spine are most free between the third and sixth cervical vertebræ, between the eleventh dorsal and second lumbar, and again between the last lumbar vertebra and the sacrum. In cases of tetanus, or in those feats of the acrobat where the body is made to rest upon the head and heels alone, this point is admirably shown. The lateral movements of the spine are very free in the neck, so as to allow of an easy carriage of the head, and in the loins, so as to permit of movement of the trunk. The movement of rotation of the spine is confined almost exclusively to the lumbar region, and it is this power of movement that enables the head to be rotated beyond the ability of movement of the atlas upon the axis, through a participation of the trunk. Holden suggests an admirable way to demonstrate this point: "Sit upright, with your head and shoulders well applied to the back of a chair; the head and neck can be rotated to the extent of 70°. Lean forward, so as to let the lumbar vertebræ come into play; you can then turn your head and neck 30° more."

The intervertebral discs are soft and of a pulpy consistency in the central portion but firm at the edges; they thus tend to form a ball and socket joint which permits of a certain amount of movement in every direction between the vertebræ which they separate. By the weight of the body they are compressed, so that at night the height of an individual is often diminished some fraction of an inch from the measurement taken after a night's repose. A habit of leaning toward one side may make a permanent deformity by destroying the elasticity of these cartilages. Thus, a distortion of the spine may not always indicate disease.

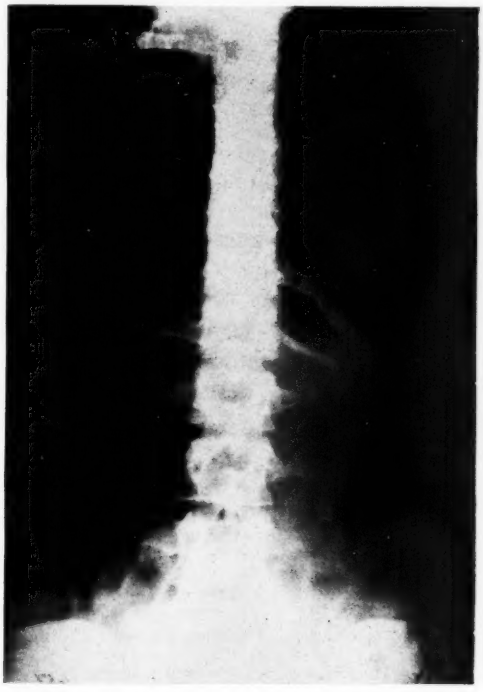

Fig. 4. Elongation of transverse processes of the first lumbar vertebra; the one on the left side resembles a first lumbar rib. If this becomes segmented, it may be confused with renal stones.

Upon each side of the spines of the vertebræ may be perceived a deep groove for the strong muscles of the back. If we look at the spinal column from the front, we perceive that the transverse processes of the atlas are very long, so that the muscles which rotate the head can gain additional leverage. An enlargement of the column can be detected at the lower part of the cervical region, whereby is formed an expand-

ed base for the neck, and a diminution in the width of the column can be detected in the dorsal region, affording more room for the lungs. A slight lateral curvature in the dorsal region may often be perceived, which is attributed by some authors to the excessive use of the right arm, since the concavity is usually toward the left side. This point should be remembered as a frequent and natural deformity when diagnosing a lateral curvature as the result of disease.

Along the entire length of the spinal column on its posterior aspect the spinous processes form a prominent bony ridge, which may be felt through the skin of the back even in the fattest persons, and which is occasionally prominent during life. It will be noticed that the spine cannot be felt in the cervical as distinctly as in the dorsal and lumbar regions, for the following reasons: (1) on account of the curve; (2) on account of the attachment of an elastic ligament (the ligamentum nuchæ), which extends from the head to the last cervical vertebra and assists the muscles in supporting the head at a right angle to the spine; (3) from the fact that the spines of the third, fourth, and fifth cervical vertebræ are made shorter than the rest so as to admit of free extension of the neck; (4) on account of the muscles which tend to render the long spine of the axis less prominent than it would otherwise be. In a muscular subject, the spines of the vertebræ of the dorsal and lumbar regions, instead of being prominent as they are in the skeleton, lie in a median depression or groove, which extends the entire length of the back and is caused by the

Fig. 5. Spina bifida occulta of the first sacral vertebra. The cleavage between the two elements of the laminæ is marked: the left element is longer than the right and curved cephalad. The right lamina forms a transverse, blunt, rounded projection ununited with the left. The patient had low back pain and this anomaly was detected on the routine examination of the spine.

Fig. 6. Spina bifida occulta of the first sacral vertebra in the female, with symptoms of low back pain.

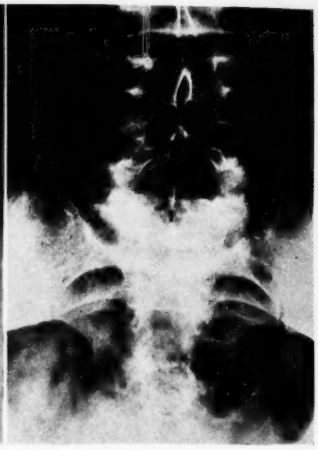

Fig. 7. Spina bifida occulta of the first sacral vertebra and congenital spondylolisthetic pelvis due to developmental anomaly of the lumbo-sacral articular processes. Female. Patient had marked lumbar lordosis, with low back pain.

prominence of the erector spinæ muscles upon either side of the spines.

The spinal canal, which is inclosed by the vertebræ, extends throughout the entire length of the spinal column and contains the spinal cord, and the lumbar, sacral, and coccygeal nerves, after the spinal cord has terminated in the cauda equina. The vertebræ so overlap each other posteriorly and at the sides that it would be extremely difficult for any cutting instrument to injure the spinal cord, except between the occiput and the arch of the atlas, where animals are usually "pithed," and in the lumbar region, where a cutting instrument might possibly injure the lumbar region or sacral nerves. The spinal canal is larger in the neck and the lumbar regions than in the dorsal, which fact is explained on two grounds: first, because there are two enlargements present on the spinal cord (where the large nerves of the upper and lower extremities arise) which demand increased space, and, second, because the dorsal region does not admit of much motion and therefore the spinal cord requires less room to insure its safety from pressure than in the neck or lumbar regions where the movements of the spinal column are more extensive.

The vertebræ are so interlocked by their spinous and articular processes as to render the danger of dislocation of any bone extremely slight. In fact, such an accident would be impossible in the dorsal and lumbar regions without a fracture of the processes having first occurred, but in the cervical region, such cases have been reported and specimens are shown in some of the large collections of osteological curiosities. Sudden and forcible rotation of the neck may be followed by such dislocation.

The excessive length of the transverse processes of the atlas affords one of the many examples of the provision to increase the leverage of muscles and thus to add to their power, since the inferior oblique muscles of the neck are thus enabled to rotate the head with greater ease than if the transverse processes were of the same length as those of the other cervical vertebræ.

The transverse ligament which serves to retain the odontoid process of the axis in close relation to the atlas, is an important structure, since it protects the medulla oblongata from the pressure which would otherwise be exerted by that process of bone when the head is bent forward; hence the fatal consequence of rupture of that ligament when hanging is performed scientifically upon a criminal. In spite of the strength of this ligament and the deep groove in the odontoid process into which it fits, it occasionally slips out of its place, with fatal results to the individual. Such displacement is more liable to occur in the child than in the adult, since in the former the ligaments are weak and liable to be more relaxed. The odontoid process of the axis is much shorter in the child than in the adult and thus more readily allows the transverse ligament to slip over its apex.

The body, being the weight-bearing part of the vertebra, is built to sustain this load. Elasticity is attained in the bodies of the vertebral column by their cancellous composition. The strongest lamellæ are arranged cephalo caudad in the direction of pressure from above downwards. These stronger vertical bars of cancellous bone are bound together by weaker horizontal lamellæ. The vertical fibers of bone are curved, with their convexities directed toward the center of the bone: the horizontal ones are slightly curved parallel with the upper and lower surfaces, and have their convexities toward the center of the bone. The vertical set is more defined than the horizontal set. The cancellous tissue of the body is covered with a thin layer of compact bone.

The number of vertebræ permits a con-

siderable amount of movement in the complete column without calling for more than a very small amount between the individual segments, thus avoiding the weakening that would result if the segments were fewer and longer. The mechanical stability of the column under all normal movements is assured by having the axis of rotation pass through the bodies and not through the arches, so that the bodies are not displaced from one another. To this end the discs join the bodies together, and the thicker the disc the greater the amount of movement between the bodies. Thus we find that the discs are thickest in the lumbar and cervical regions, where movement is most free, and shallow in the dorsal series, where naturally the amount of motion is much restricted. In addition to the intervertebral discs we find the bodies attached by the anterior and posterior common ligaments. The whole series of bodies form a flexible column, with the discs ensheathed in a white fibrous covering.

It is evident that a forward bending of the column will lead to a separation between the corresponding laminæ and spines, and thus we find that the laminæ are connected with those above and below by inter-laminar ligaments (ligamenta subflava), mostly pure elastic tissue. The separation of the transverse processes in lateral flexion of the column is met by the intertransverse muscles and considerable white fibrous tissue. Lateral flexion is more limited than ventral flexion.

We may sum up the movements between the parts of the different vertebræ as follows: the bodies being in and around the center of motion or gravity move least, and the various processes move more, in proportion as they are far away from the body in the plane of any specific movement. The cord, with its meninges, lies deep to the neural arch. This arch moves away from or to its neighbors in flexion or extension and thus the cord obtains the greatest possible amount of freedom from action by having no attachments to the arches. The cord is held to the dorsal aspect of the corporeal column by the adhesion of the pachymeninges to the dorsal common ligament and by the attachment of its nerves to the pedicles and discs through their sheaths of dura mater.

CHRONOLOGIC CHANGES OF THE SPINE

The detailed examination of the roentgenograph of the spine at different ages is necessary before the student is able to pass a reliable opinion. He should note changes in size, shape, position, relations, and density of the segments of the vertebral column and should keep in mind the sequence of phenomena that takes place in endochondral ossification of the vertebral pillar of support and laminar protection. The general outline of the bones should be compared with a known standard. Irregularities, lipping, exostoses, and radiability of the periosteum must be considered. The reliability of a roentgenologist's report of objective observations (not clinical diagnoses) rests upon keen observation and wide clinical experience. A normal or standard must be set as to the normal densities of the bones and surrounding parts of the vertebral column at different anatomic ages. Then, and then only, is he able to report objectively with assurance and certitude in cases of nutritional disturbances whether or not there has been an increase or decrease of surface, outline, or density of bone in the various vertebræ.

Changes in the epiphyseal lines due to infection, trauma, or disturbed nutrition depend upon a knowledge of the normal, and the degree of variation from the normal depends upon the criterion or standard that has been set by observational study. This variable standard, which changes with progressive development and the anatomic age,

once definitely fixed in the mind of the roentgenologist, makes possible the interpretation of even a slight degree of irregularity due to disease. It should be noted whether or not the epiphyses of the various segments have appeared, and, if so, what their density, their condition, and their size.

According to Rotch (1910) we must admit that we are studying histology and pathology in its most important aspect, that is, under living conditions, and that a knowledge of these conditions is exceedingly valuable not only for diagnosis but for treatment. We must remember that although the knowledge we obtain from the microscope is of very great value, yet at times macroscopic are as useful as microscopic pictures. A magnifying glass is of great use in studying reproductions of roentgenography of the spine. This glass is also of use in the study of the chronologic and anatomic changes of the developing spine.

The vertebræ are ossified by the endochondral method. The cartilaginous structure has a centrum and two separate halves of a neural arch, with the varying processes represented at first only by the scleroblastemal skeleton, into which the chondrifying process takes place. Ossification begins during the seventh week by the formation of three primary centers, one for the centrum of body and one for each half of the neural arch. The center for the body is either bilobed or double in origin, fusing rapidly into one bilobed center of ossification.

In the radiograph the ossifying process is not detected prior to the ninth week. At this time the centers for the arches of the cervical vertebræ appear, progressively in order from above downward. While each part passes through its own cycle of changes, these changes as a whole tend to follow the law of *developmental direction;* for it is generally found that development, including growth and differentiation in the long axis of the body, appears first in the cephalic aspect of the body and progresses caudad, and, similarly, development in the transverse plane begins in the mid-dorsal region and progresses laterad and ventrad, while in the extremities it extends proximodistad.

The primary centers of ossification appear, therefore, at different times in different regions: thus, those for the *arches* appear first in the cervical region (*axis*), and succeed one another from above downwards, while the *centrum* ossifies earliest in the mid-dorsal regions and extends thence in both directions, cephalad and caudad. The ossification of the arches is associated with the determinant induced changes caused by the progressive development of the musculature from above downwards: the ossification of the bodies of the vertebræ with the first appearance of an adequate optimum location of pressure.

The cervical *arches,* therefore, ossify before the *bodies,* while in the mid and lower dorsal and lumbar regions the *bodies* ossify before their corresponding *arches.* The rapidity of the extension of ossification has individual variations but by the end of the third month there are primary centers for all the true or movable vertebræ (cervical, dorsal, and lumbar).

At birth the three primary bone centers are distinct, but joined by cartilage. The arches join dorsally during the first year; fusion commences in the lumbar region. A few years later the arches join the bodies; this process commences in the dorsal region.

After puberty secondary centers appear and fuse with the primary bone by the age of twenty-one. These appear in the cartilage covering the upper and lower surfaces of the body, epiphyseal plates, and the tips of the transverse and spinous processes. The epiphyses of the body ossify only at the periphery of the cartilaginous plate, the central part remaining cartilaginous, but in advanced life this also may be ossified.

At the seventh intra-uterine month there is seen a rudimentary atlas and axis and then the vertebral column through its whole length. Especially marked is the extreme radiability of the intervertebral discs in comparison with the lessened radiability of the bodies of the vertebræ, which, however, also show a cartilaginous condition of the transverse processes throughout the whole length of the spine. Starting from above it should be noted in comparison with the radiability in the cardiac region, where the density of the heart is added to that of the spine.

At the sixth month of extra-uterine life the radiability has gradually decreased, due to increased ossification of the vertebræ, whereas at two years the transverse processes of the cervical vertebræ are considerably condensed and cast a shadow. At the third year there is no especial change in the density of the cervical vertebræ. The lumbar vertebræ are, however, unusually distinct and show decidedly lessened radiability in their bodies. During the sixth year the bodies and the transverse processes have become much more ossified and have greater density and lessened radiability.

ANOMALIES OF THE HUMAN SPINE

The malformations of the human embryo resemble in a general way—and frequently in detail—the anomalies of the lower forms produced by experimental means. There may be a similarity in the causation of them. In the lower forms, abnormalities of growth are produced artificially by interfering with the normal course of development of the egg, producing changes in the usual conditions of nutrition and growth. The interfering agent may be biochemical or bio-mechanical or both. Mall (1908) considers that a faulty implantation of the ovum due to some form of endometritis results in human monsters.

The works of Dareste (1891), Bardeen (1908-9), Newman (1917), Child (1911), Stockard (1909-21), Bagg (1922-24), Baldwin (1919), and the Hertwigs (1910 and 1916) have emphasized the fact that all developmental monstrosities are the results of simple arrest. Various factors suffice to produce retardation in the embryonic developmental rate. These retarding factors may be defective oxygenation, excessive carbon dioxid, anesthetics, mechanical disturbances, lowering of temperature, various chemicals (lithium, sodium, potassium and magnesium salts), irradiation with actinic substances, mechanical interference by foreign bodies, chemical poisons of maternal syphilis, blood produced by pre-eclamptic toxemia. All these and shock, worry, and starvation cause nutritional disturbances in the endometrium by vascular changes. The retarding influence varies in its effects according to the length of time of exposure and the intensity of action. The action may be so profound as to cause abortion or death of the ovum or embryo or fetus.

In the lower forms Hertwig (1892) has produced spina bifida in *Axolote* by treating the eggs with 0.7 per cent solution of sodium chloride. The same abnormality has been evident when fertilized frog eggs have been treated with 0.6 per cent solution of sodium chloride (Morgan, 1895). Bardeen (1907-9-11), from extensive work with toads and frogs, found that ova, sperm, and the zygote are susceptible to X-rays. He produced spina bifida in these experiments.

Ever since the discovery in November, 1895, by Professor Wilhelm Konrad Röntgen, of the University of Würzburg, of the peculiar properties of a group of cathode rays of light, which, because of their remarkable penetrating power, render it possible to photograph substances through certain other substances that are opaque to

ordinary light, much interest has been manifested as to the effect of these rays on various tissues under different conditions. Many observers have evidence that there is a specificity of tissue reaction to the selective absorption of X-ray energy. This is due to a chemical reaction of an intracellular character.

Stockard (1907) has produced an interesting anomaly, *Cyclopia,* of the cranial vertebra. He subjected the eggs of *Fundulus* to a 50 per cent solution of magnesium chloride. The artificially produced single median cyclopean eye resulted from subjecting the fish embryo, *Fundulus,* to sea water solutions of magnesium chloride.

It is well known that the growing tissues are more vulnerable, and their power of resistance less when their complete development has not taken place. The tissues of early life are open not only to specific infections, but to numberless as yet undifferentiated varieties of pathogenic microorganisms which are but little understood. The effects, however, which these organisms have upon the normal growth of the various tissues and the abnormalities which may result from delayed or perverted normal anatomic conditions are recognized, and these conditions are shown in what are called malformations. By means of the roentgen-ray method of examination the question of corrective measures and the prognosis in regard to future use are made possible.

The spinal column may show an absence of one or more vertebræ, or an additional vertebra, fusion of vertebræ, retarded or accelerated growth of parts, or complete inhibition of parts of vertebræ. In addition, it may show abnormal lordosis, kyphosis, or scoliosis. The condition of craniorachischisis (see Dorland and Hubeny, "The X-ray in Embryology and Obstetrics," after Carey) is one of the principal forms of congenital defect of the spine, but though a roentgenograph of this condition might be interesting from an embryologic viewpoint, the malformation is so evident at birth that the roentgen ray for diagnosis is unnecessary. It is a disease of pathologic rather than of clinical interest, for not only is there a deficiency of the vertebral arches but the cord itself is rudimentary. Fusion of vertebræ with contiguous bones, such as the atlas with the occiput and transverse process of the fifth lumbar with the ilium, forming a sacralization, may occur. Half vertebræ may cause congenital scoliosis. Figures 1 to 7 illustrate some of these anomalies of the spine of clinical interest.

In the study of each case the vertebræ should be counted and we should note whether the intervertebral discs are distinct, or are compressed, fused, or destroyed. The number of vertebræ may be increased or diminished, deficiency in one region usually being replaced by an additional vertebra in another. It is to be noted, however, that the number of bones in the cervical region is rarely increased or diminished. An additional or lessened number of vertebræ in the lumbar region is of especial interest in connection with the technic of lumbar puncture.

Spina bifida.—The most common disease of the spine which occurs during intra-uterine life is spina bifida. This condition is getting to be of additional importance, since by means of the roentgen-ray method considerable advances have been made in the treatment of these cases through the more precise diagnosis which can be attained by detecting the exact type, locality, and extent of the lesion before operation. Spina bifida is a condition in which there is a failure of closure of the laminæ of the vertebræ. At certain intra-uterine periods this anatomic condition is normal, but when it is found at full term it becomes abnormal from a developmental point of view and represents a distinct malformation. The

laminæ close normally at the beginning of the fourth month of fetal life and fusion takes place at the base of the spinous processes from above downwards. As the lumbar vertebræ are the last to unite, spina bifida is most common in the lumbar region. A true spina bifida commonly appears as a tumor in the lower part of the spine or in the sacrum, and is covered with either healthy or diseased tissue, which is usually very thin and transparent. At times the tumor is solid, containing only fibrous and fatty tissue, with no connection with the spinal cord or canal other than a dense fibrous pedicle with no nerve tissue or filaments included. At other times it may be represented simply by a defect in the skin, usually covered by a tuft of coarse hair; in this latter case it is called spina bifida occulta. The condition of pylo-nidal-sinus must of course be thought of differentially, but usually can be readily distinguished from spina bifida.

CONCLUSION

The normal living anatomy of the spine as studied by the roentgenograph, as well as the variations, physiology, chronologic changes, and anomalies of the spinal column, have a decided clinical importance. These fundamental facts must be mastered if the roentgenologist is to avoid errors of diagnosis. The importance of this study of normal living anatomy by means of the X-ray for all medical students has been recently emphasized by Bardeen, Carey and Moody. This work should be a part of the activities carried on by students in the department of anatomy.

Note:—Acknowledgment is made to Mr. Leo Massopust, Department Artist, for his aid in the preparation of the illustrations.

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DISCUSSION

DR. L. T. LEWALD (New York): This is too valuable and important a contribution to go without a few words, and I personally was particularly interested in Dr. Carey's discussion of some of the congenital phenomena. I would like to ask Dr. Carey in regard to *achondroplasia,* whether he regards this (when we see the type that goes on to complete development of the individual) as does Dr. Stockard, that it is not to be regarded as a pathological condition. Stockard says that he could raise a whole race of achondroplasiacs, and he simply regards this as a variation of the human species. I wish Dr. Carey would clear up a point that I have trouble with, in regard to the question of a long transverse process of the seventh cervical, which some surgeons believe is equivalent to a short *cervical rib,* and gives symptoms requiring operation. I wish to ask Dr. Carey if, in his experience, he has seen this condition and whether one could have a short cervical rib of about an inch or an inch and a half in length. In connection with Dr. Carey's remarks concerning a fracture of a cervical rib, I would like to call attention to the fact that a cervical rib may be developed in two parts. I have seen at least three cases in which there is a sort of false joint about half way down on the cervical rib, which might look like a previous fracture with lack of union and the production of a false joint. Some of the cervical ribs have also apparently fused with either the clavicle or first rib. I have seen thirty or forty cases of cervical ribs and only two cases that required operation. I would also like to ask Dr. Carey, because the question is constantly coming up, as to whether the anomalies of the fifth lumbar weaken the spine. Some authority has stated that a person who has an *anomalous development of the fifth lumbar* is a weakened individual. The question comes up in compensation cases as to whether the previous existence of this condition renders a person who has a trauma more likely to have symptoms following it, or whether he only thinks he has them. I am sorry Dr. George is not here, because Dr. George has furnished the Compensation Commission in his locality with radiographs of these anomalies. I think that the more we make known about these anomalies, the better able we shall be to properly adjust insurance cases. In fact, it would be wise for an employer to have radiographs made of his employees when he hires them so that anomalies will not be mistaken for injuries later. One other anomaly I showed recently is not very well known. It is not related to the spine, but I mention it here; it is a *double patella,* in which the patella is developed in two centers and could easily be mistaken for fracture. There are two cases reported in Grashey's *Atlas,* and I have seen two cases.

DR. I. S. TROSTLER (Chicago): I will report what was, to me, a rather interesting incident in regard to spinal condition in a professional baseball player. A member of the Chicago team (I think it was the Cubs) was playing in St. Louis and was supposed to have wrenched or injured his back. He was immediately sent to a hospital where an X-ray examination was made and he then was sent home to Chicago. He was sent to one of the Chicago hospitals, another roentgen examination carried out, and a diagnosis made by the roentgenologist of fracture of the arch of the fifth lumbar vertebra. That is pretty deep down, and the physician for the baseball club, a personal friend of mine, called me up and said, "What do you think of the possibility of that?" I said, "It might be done, but it is pretty farfetched." The films showed simply a failure of the closure of the arch of the fifth lumbar. That is a common anomaly, a deformity that Dr. Cushway, in his

railroad examinations, has found in nearly 20 per cent of normal spines. I told the doctor that, and the baseball player pitched the same afternoon.

DR. CAREY (closing): In regard to Dr. LeWald's statement regarding achondroplasia and the work of Stockard, I wish to mention that the achondroplasia may be one of degree, may have a congenital wart, or there may be a congenital absence of the development of bone in the cartilage. Achondroplasia is not confined to any particular type of deformity. There may be innumerable types of deformities, depending upon the type that the process tending to produce these changes manifested itself in, in the embryo. According to Stockard's own experiments on fish embryos, he was able to produce various types of deformity in various soft parts by bringing deleterious influences to bear at the time that the growth rate was going on at the maximum in those parts. For instance, that fetus amorphus shown on the screen,—if those deleterious influences were brought to bear at that particular time, the rapidly growing core of the skeleton would tend to be inhibited because its growth rate is going on at the maximum at that period. If the limb had developed a little further before cold was brought to bear on the growing embryo, there would be a deformity or retardation in the rate of growth or complete absence of the distal element in that particular limb. Achondroplasia may either lead to a complete arrest of growth or retardation of growth. Therefore these congenital deformities would be of varying degrees. Also, a proliferation of the cartilage would lessen the degree of elongation of the skeleton. About a double patella—I would like to ask Dr. LeWald if that case was ever dissected.

DR. LEWALD: No, neither of these cases had any further observation.

DR. CAREY (resuming): I might mention at this point some experimental work that we are carrying on at the present time in the regeneration of the patella. We find that in young dogs you can completely excise the patella, putting the limb in a cast for seven or eight days to permit preliminary healing and allowing the dogs to run around, and inside of thirty to forty days there will be a complete regeneration of the patella, providing the suturing has remained intact. We find that by ankylosing the knee and leaving the patella intact on that particular side, the patella undergoes atrophy. In one case we obtained in the regeneration a double patella and found that there was a complete splitting of the tendon of the quadriceps extensor muscle and two different patellæ developed in each one of them.

The point that Dr. LeWald mentioned in regard to the relationship of an anomalous development of the fifth lumbar vertebra and a weak back,—I wish to state that sufficient data have not been gathered on this point up to the present time to make a positive affirmation. Dr. Cushway, Dr. Bohart, and Dr. Maier are compiling statistics at the present time regarding this relationship. The other point in regard to a cervical rib—I do not think that has been studied sufficiently for me to give an answer regarding it.

THE EFFECT OF ROENTGEN RAYS ON THE DEVELOPMENT OF TUBERCULOSIS IN GUINEA PIGS[1]

By FRANCES A. FORD, M.D., Section on Roentgen-ray Therapy, Mayo Clinic, Rochester, Minnesota

ALTHOUGH roentgen rays have been used in the treatment of tuberculosis since shortly after their discovery in 1895, there are still conflicting views as to the efficacy of such treatment and the mechanism underlying their action. Correct evaluation of the early experimental work in this field is difficult in terms of modern roentgen-ray treatment, since with the apparatus used at that time (the Ruhmkorff coil and Crookes tube) dosages were inaccurately calibrated and inexactly expressed. It has seemed to me advisable, therefore, to repeat some of the early experiments with roentgen rays of penetration corresponding to present-day usage in the treatment of tuberculosis in man. The dosage was adjusted to amounts tolerated by a normal guinea pig for a sufficient length of time to enable one to observe the effects of roentgen rays on the development of the disease.

REVIEW OF LITERATURE

In 1898 Bergonié and Tessier attempted to demonstrate a possible bactericidal action of roentgen rays on the bacillus of tuberculosis and established the fact that the rays had no demonstrable effect on the structure or the virulence of the bacillus *in vitro*. Lortet and Genoud, in 1896, subjected to the action of roentgen rays guinea pigs that had been inoculated with the bacillus of tuberculosis, and found that after a few weeks of treatment these animals were apparently healthy and the sites of inoculation scarcely discernible, whereas the untreated control animals presented abscesses and swollen regional nodes.

Bergonié and Tessier continued similar experiments, inoculating guinea pigs by intraperitoneal, intrapleural, and intratracheal routes, and subjecting part of each group to irradiation. On postmortem examination the majority of the animals treated presented sclerosis of the pleura and thickening of the peritoneum which the authors construed as a defense action against the tuberculous infection. They cautioned against the application of such methods of treating tuberculosis in man without further investigation, pointing out the possible danger of a widespread fibrotic change, as well as the finding in numerous instances of petechial intestinal hemorrhages and other evidences of irritation from the rays. They mentioned too the clinical observation of increased respiration, lowered blood pressure, and altered nutrition due to irradiation, as possible harmful results.

Mühsam, in 1898, also working with guinea pigs inoculated with the bacillus of tuberculosis, found that irradiated animals lived longer (seven to forty-five days) than the controls. His studies led him to the conclusions that roentgen rays cannot cure generalized tuberculosis in animals, but will reduce or limit a local lesion, and that it had not been proved by experiments thus far conducted that roentgen rays would definitely cure the disease.

Rohde conducted similar experiments, using ultra-violet rays produced by a quartz lamp as a therapeutic agent, with comparable results, and concluded that the artificial sunlight has a specific effect on the bacillus of tuberculosis and its products, and also a general effect on the organism.

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[1]Abridgment of thesis submitted to the Faculty of the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of Master of Science in Medicine, December, 1926.

Work done in the Division of Experimental Surgery and Pathology, Institute of Experimental Medicine, The Mayo Foundation.

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Brüning and Albrecht made a comparative study of sunlight, ultra-violet and roentgen rays in the treatment of rabbits suffering from laryngeal tuberculosis. They found that by far the most intensive effect was from the roentgen rays, the animals so treated showing encapsulated diseased tissue as opposed to dense infiltration and necrosis in the other groups.

Küpferle and Bacmeister, studying pulmonary tuberculosis in rabbits, concluded that a definite effect is produced by hard roentgen rays in large doses, the typical proliferation tissue being destroyed and replaced by fibrous connective tissue. As opposed to Küpferle and Bacmeister's favorable results with hard roentgen rays, Stephan, in 1920, suggested the use of soft roentgen rays in small doses to increase the vitality of the cell through a stimulating effect. He regarded the epithelioid zone of the tubercle as a defense mechanism which should not be destroyed. The basis for this theory was the clinical experience that, with the smaller dosages of roentgen rays of softer quality which were necessarily delivered by the older forms of roentgen-ray apparatus, the therapeutic results were on the whole more favorable than with the large doses of filtered roentgen rays which came into use with the development of the Coolidge tube and other improvements in roentgen-ray production.

Ritter and Moja, in 1923, treated guinea pigs with varying doses of roentgen rays and obtained the most favorable results with a moderate dose of unfiltered rays (20 times surface dose); the histologic result they described as a formation of heavy connective tissue which surrounded the tuberculous focus. These authors note, however, that this conclusion is not directly applicable in the treatment of tuberculosis in man because of the relatively superficial position of the affected nodes in guinea pigs, which makes them more accessible to superficial doses of roentgen rays. They agree with Stephan that the purpose of roentgen-ray treatment is to stimulate the body in its fight against disease, and they recommend light dosage.

In general, the experiments referred to are open to the criticism that the dosage of roentgen rays is inadequately defined, that, as a rule, small groups of animals were used in each experiment, and often that the work was done without controls. In many experiments, too, sufficient time was not allowed for the development of typical tuberculous lesions before the animals were killed.

Murphy, in 1915, in connection with studies of the rôle of lymphocytes in reaction against disease, demonstrated that by carefully graded doses of roentgen rays it was possible almost completely to deplete mice of lymphoid tissue without any appreciable effect on other tissues or on the general health. He confirmed Lewis' finding that splenectomy, although followed immediately by reduction in circulating lymphocytes, after nineteen to twenty-one days produces definite lymphocytosis in about 75 to 80 per cent of the animals. Murphy accordingly inoculated with tuberculosis mice that had been splenectomized and subsequently treated with roentgen rays; mice that had been treated with roentgen rays only; mice that had been splenectomized only, and mice that were normal or untreated. The animals in the first two groups lived an average of nine days after inoculation. Those splenectomized three and one-half weeks previous to inoculation lived an average of twenty-six days after inoculation. The untreated animals lived an average of eighteen days. He concluded from this that the lymphocytes play an essential part in the resistance of mice to tuberculosis.

The work of Lewis and Margot has suggested that there may be some factor other than the lymphocytes affecting the resistance of mice to tuberculosis. After establishing the fact that splenectomized mice have in-

creased resistance they found that this could again be decreased if the same animals were fed fresh spleen. They accordingly fed different groups of mice extracts from the fresh spleen, stomach, duodenum or liver, until the animals developed tolerance against the toxic reaction of such tissue as food. They were then inoculated, and mice that had been splenectomized only, and also untreated mice, were used as controls. Feedings of the various tissues were continued during the experiment and it was noted that, whereas the normal mice were dead by the second day, the splenectomized mice lived much longer, forty-two to eighty-nine days; those that had received fresh spleen in their food exhibited the effect of neutralization of splenectomy, while those that had been fed the extract of stomach and small intestine did not have any reduction of their span of life. Lewis postulates a substance in the spleen that he calls "tuberculosplenatin," which he believes may make the animal more susceptible to the invasion of the bacillus of tuberculosis. Lymphocytosis following splenectomy had not been affected by the feeding of the spleen extract. Lewis supposes that the removal of the tuberculosplenatin may limit the action of the lymphocytes in defense reactions.

In 1916 Morton established the fact that by exposing guinea pigs to relatively large doses of roentgen rays the time required for the development of tuberculosis following inoculation could be materially reduced. This work was confirmed in 1917 by McGrath, who found also that the roentgen-ray exposure might precede the inoculation by an indefinite period and still render the animal more susceptible to a rapid development of tuberculosis.

More recently Murphy has shown that roentgen rays produced at a low voltage (¾ inch spark gap) in a tube of especially thin glass, will have a distinctly stimulating effect on the number of leukocytes in the circulating blood stream. This stimulating effect is continued *in vitro* on suspensions of lymphoid tissue, by serum from animals irradiated at the low voltage.

COMMENT

It is apparent from the preceding review that the effect of roentgen rays on the defense reactions of the animal or human body may be extremely complex, and that this question has been inadequately investigated. All together, the conditions of animal experimentation bring in many confusing issues, such as (1) the susceptibility of each genus of animal to tuberculosis; (2) the practical necessity of irradiating the entire body in small animals, and (3) the involvement thereby of the problem of computing comparable dosages. In view of the diverse results so far presented from such experimentation I determined to repeat the inoculation of guinea pigs with the bacillus of tuberculosis, and subsequently treat a group at dosages of roentgen rays of a frequency comparable to that now being used in the treatment of human beings, and to maintain an adequate group of control animals. The extremes of roentgen-ray frequency, such as the 200 K.V. which is used to some extent in treatment for tuberculosis in Europe, and the low voltages used by Murphy and his coworkers, were not considered.

METHOD OF INVESTIGATION

I used a Kelley-Koett roentgen-ray apparatus with an autotransformer and a Coolidge universal tube of broad focus. The voltage was calibrated on each day of treatment by means of a blunt-point spark gap mounted in the circuit. Three voltages were selected to cover a range of dosage which is in current therapeutic use in tuberculous peritonitis or adenitis. The hardest rays were obtained by means of a 9-inch spark gap with 4-mm. aluminum filter, the ray of medium grade penetrability, with a 6-inch spark gap and 2-mm. aluminum filter, and the softest ray with 3¾-inch spark gap

and without filter. For convenience of exposure the guinea pigs were placed in small boxes of thin cardboard, with a cover irregularly perforated. That the experimental conditions might be closely analogous to clinical methods of treatment I wished to select a dose which could be repeated weekly for several weeks to secure a continuous roentgen-ray effect. A 1-minute exposure with a 5-ma. current and 9-inch focal skin distance was chosen, which proved to be approximately one-eighth erythema dose for human skin for each setting. In the course of the preliminary studies it was found that guinea pigs, on the average, survived this dose without marked loss of weight or serious changes in the blood for from eight to ten weeks. Early attempts to use a dosage comparable to that employed by Morton and McGrath were unsuccessful, the guinea pigs invariably succumbing from a few days to two weeks after exposure. It has been my experience that in the week following the first roentgen-ray exposure, a rather high percentage of deaths occurs, even though the dose is graded to an amount which guinea pigs, after surviving the first dose, will tolerate easily for several weeks. This was attributed to a possible early initial lowering of general resistance to intercurrent infection.

RESULTS OF EXPERIMENTS

Weights recorded weekly showed that the dosage indicated can be tolerated by the guinea pigs for several treatments without a drop in body weight. As a rule, a fall of 100 gm. is significant of over-exposure to roentgen rays, and unless treatment is suspended for a time, death occurs. Conjunctivitis and blepharitis has been a second warning symptom, being present as a rule only late in the course of treatment when tolerance is much reduced. A test group of seven guinea pigs survived on an average 8.9 consecutive weekly treatments at setting indicated with 9-inch spark gap; from seven to ten treatments were given.

The hemoglobin determinations of an unselected group of treated and control animals showed that for a period of eight weeks with weekly treatments, the hemoglobin of treated animals had not fallen more rapidly than that for untreated animals. In this as in other blood counts relative dehydration of tissues of the treated animals may obscure actual effects.

Although the total leukocyte count in guinea pigs is subject to marked fluctuation, the counts of treated animals, as opposed to untreated, indicate a definite reduction in leukocytes with continued treatment by roentgen rays. Unusually few leukocytes, from 1,200 to 3,000, were counted in some animals shortly before death. In this reduction it has seemed that the lymphocytes decreased proportionately to the fall in the total leukocytes as shown by the relatively constant level of the percentage of lymphocytes, and also the similarity of trend of the fall of the total lymphocytes to that of the decrease in total leukocytes.

Having determined that guinea pigs could be maintained in fair health for a period of several weeks at the various dosages selected during the time tuberculous infection might develop and be influenced by treatment, I inoculated[2] fifty-two guinea pigs intraperitoneally with an emulsion of the bacillus of tuberculosis. Twenty-six of the animals were maintained as controls. Eight of the animals (hereafter referred to as Group 1) were treated weekly with 1-minute exposures at a 9-inch spark gap and 4-mm. aluminum filter (with the other factors as stated previously); six (Group 2) were treated similarly with a 6-inch spark gap and 2-mm. aluminum filter; and six (Group 3) with a 3¾-inch spark gap without filter, while six animals (Group 4)

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[2] I am indebted to Dr. T. B. Magath for his co-operation in preparing the cultures and inoculating the guinea pigs; and also to Dr. A. C. Broders for the pathologic studies.

received daily ultra-violet exposures with increasing dosage. The guinea pigs of the latter group were not epilated. The eyes were protected during radiation by small pieces of cardboard, and during the course of ultra-violet treatment no evidence of conjunctivitis appeared. Exposures were started at two minutes and increased to twenty minutes. The weekly weights and blood counts were discontinued as being unessential, the results of the experiment being judged on longevity and postmortem findings. A few deaths occurring in each group immediately after inoculation were disregarded, as this is a frequent occurrence with guinea pigs in any experimental work involving handling and inoculation. The early death rate in the irradiated group was slightly higher than in that of the untreated group, while after the first three weeks the rates ran almost parallel. The first positive postmortem report of tuberculosis in the irradiated group was of an animal dying the fifteenth day after inoculation, and all subsequent necropsies of irradiated animals revealed tuberculosis. The first positive report from the control group was on the twenty-third day. Of six guinea pigs in the control group which died between the twenty-third and twenty-eighth days after inoculation, four showed tuberculosis on necropsy. After the fourth week all of the controls exhibited tuberculosis. Whether this fact supports Morton's and McGrath's finding that roentgen rays contribute toward the early development of tuberculosis is doubtful. The difference noted is not great and the individual resistance of the guinea pigs to tuberculosis may be the only factor in longevity. It was evident that the bacillus of tuberculosis was extremely virulent and that a high dose of infective organism was used, as all of the animals showed widespread tuberculosis. The pathologist was unable to differentiate the treated and untreated animals by any morphological characteristics.

The seven animals in Group 1 that developed tuberculosis survived from fifteen to forty-eight days. The eighth animal had succumbed ten days after inoculation but there was some question whether the necropsy report was indicative of tuberculosis. Five in Group 2 developed tuberculosis and died in twenty-four to forty-eight days. The four animals in Group 3 that developed the disease survived from seventeen to sixty days. In Group 4 no deaths occurred until the thirty-fourth day. All the animals in this group developed tuberculosis and succumbed in thirty-four to forty-eight days. In the control group twenty of the twenty-six guinea pigs developed tuberculosis and survived from twenty-three to sixty-nine days after inoculation.

SUMMARY

With the dosage of roentgen rays selected as being comparable in penetration to that used in the treatment of human beings it was not possible to check or retard the course of development of a virulent infection of tuberculosis in guinea pigs. The fact, however, that guinea pigs are unusually susceptible to tuberculosis, that the treatment of small animals necessarily is applied to the entire body, which undoubtedly alters the therapeutic result, and that the virulence of infecting organism in this case apparently was overwhelming, prevents the data presented here from being conclusive evidence that roentgen rays are without influence on a generalized tuberculous infection. It is possible that a less virulent infection would permit a demonstration of defense reaction not exhibited in the present study; also that in localized tuberculosis other resistance factors may be involved.

Morton's belief that roentgen rays tend toward earlier development of tuberculosis receives some support from these data, especially in the group treated with larger doses of roentgen rays. The difference,

however, in the development of disease in the treated group and control group is slight.

Ultra-violet exposures did not prevent the development of tuberculosis in the group of six guinea pigs. The deaths in this group occurred relatively late, as there were no early deaths from intercurrent infections.

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PHYSICAL AND BIOLOGICAL OBSERVATIONS ABOUT SKIN REACTIONS[1]

By A. BACHEM, PH.D., Professor of Biophysics, University of Illinois College of Medicine, CHICAGO

IN several publications I have shown that the erythema dose is a very poorly defined term, and its application is rather uncertain. This is the more deplorable because the erythema dose is considered as a unit, as well for the comparison of surface applications as for the determination of internal applications in deep therapy.

Five years ago I compared (1) several erythema doses and detected differences of more than 50 per cent; at the same time I determined that a much larger dose of hard rays should be absorbed if the same biological effect is to be produced as with soft rays. Several years later my measurements were confirmed by Martius and Grebe (2), who discovered ratios of 1 to 4 between the lowest and highest so-called erythema doses. In order to overcome these considerable discrepancies, I have tried to improve the two methods which were available for the determination of dosage.

The first is known as the indirect method of using the electrical and mechanical factors of the production of X-rays for the dosage calculation. This method had resulted in several dosage formulas. In previous papers (3, 4, 5, 6) I have criticized these formulas and replaced them by a dosage scheme based upon my own observations. This scheme is given by the following formula:

$$\text{Erythema time in minutes} = \frac{\text{focus skin distance}^2\ \text{(inches)} \times K}{\text{spark gap}^2\ \text{(inches)} \times \text{milliampere}}$$

"K" is an empirical factor, the significance of which will be taken up later.

It was my intention to put this treatment scheme, which I had suggested provisionally, on a broader foundation. For this purpose I have sent a circular to most of the radiologists in this country, who do X-ray treatment work on a large scale, inquiring about their treatment conditions for the production of several skin reactions. Practically all of these circulars (46) were answered, and I am glad to say that their answers were proof of very careful and responsible observations. I gladly give credit and express my thanks for this collaboration to the radiologists of this country. Altogether I received the data of 250 erythema, epilation and similar doses. All these data have been used for the control of my dosage scheme, by calculating the factor "K" from the treatment data. This represents the strength of the applied dose for a given filter in the terms of gap, milliamperage, focus skin distance, and time, all these factors being properly weighed. As far as different filtration is concerned, it represents the time increase necessary to overcome the decrease of intensity due to the filter absorption. The end-results and the statistics are given in Chart I.

The first column gives the filter used, in millimeter thickness. The aluminum filters ranged from 1 to 6 mm.; the copper filters from 1/4 to 4/4 mm. + 1 mm. aluminum. The approximate aluminum equivalent is given too, for the various copper filters.

The second column gives the lowest, highest, and medium gaps used with the respective filters. The medium gap coincides practically with the gap which I am using and which I have advocated for therapeutic use (6).

[1]Read before the Radiological Society of North America, at Milwaukee, Nov. 29, 1926.

CHART 1

1	2	K					
		3	4	5	6	7	8
Filter (mm.)	Spark gap (inches)	Scheme figures	Sheldon's figures	Radiologists' figures	Experimental figures	Formula Figure A	Formula Figure B
0	3 6 9	5 6 12	(0)	5 6.5 12.5	3.3 6.5	6	4
1 Al.	4 6 8	9 11 22	15	11 22 39		12	9
2 Al.	6 8 9	12 18 36	31	---- 34 ----	22 23	20	16
3 Al.	6 8 10	19 27 54	46	29 35 42		30	25
4 Al.	6 9 10	25 36 72	62	42 40 52	55 55	42	36
5 Al.	8 9 10	32 46 92	77	---- ---- 67		56	49
6 Al.	8 10 12	40 57 110	93	---- 65 87		72	64
1/4 Cu. + 1 Al. (8 Al.)	9 10 12	45 69 125		87 131 145		110	100
2/4 Cu. + 1 Al. (10 Al.)	11 12 15	91 130 225		152 181 271		156	144
3/4 Cu. + 1 Al. (12 Al.)	12 14 15	133 190 310		164 235 267		210	196
4/4 Cu. + 1 Al. (14 Al.)	12 14 15	175 250 400		223 340 398		272	256

In the third column the "K" figures are given from my dosage formula, for a skin unit dose, a mild and a pronounced erythema.

The fourth column shows the corresponding figures from Sheldon's formula for aluminum filtration. A comparison indicates that they are higher than my figures, particularly for higher filtration; they represent more a pronounced than a mild erythema, for the average transformer. The formula of Sheldon does not apply to unfiltered radiation.

In the fifth column I have put down the average figures from the data from the responses of the radiologists, for an epilation,

a mild erythema, and a pronounced erythema with desquamation and occasional blistering. These figures were calculated from my formula:

$$t = \frac{\text{F.S.D.}^2 \times K}{\text{spark gap}^2 \times \text{ma.}}$$

by inverting the formula in

$$K = \frac{\text{spark gap}^2 \times \text{ma.} \times t}{\text{F.S.D.}^2}$$

and replacing the symbols by the given treatment figures. The results were classified under the three reactions and the various filters and then averaged.

Within each group marked variations exist, due mainly to two causes: the different output of the X-ray equipments and the difference in the biological reaction. This variation was comparatively low for copper filtered rays; for the erythema dose with 3/4 mm. copper, *e.g.*, the lowest figure, was 147, the highest 300, which means a difference against the average 240, of —38 and +25 per cent.

The variation was extremely pronounced for erythema doses with unfiltered rays. While the average figure was 7, the lowest figures were 1.4, 1.5, and 1.8; the highest figures were 28, 18, and 10. The same two reasons can be made responsible for this: The variability of the output of the tube, which is very pronounced in unfiltered technic, due to the different thickness of the glass, the variation of the deposit on the glass and the condition of the target; and the variability of the reaction which is termed an erythema. It seems to me that the lowest figures do not actually produce an erythema, and that the highest figures belong to inefficient tubes. In all other conditions the figures remain within reasonable limits, just indicating the inaccuracy which exists due to the output variation and the uncertainty of the determination of an erythema.

A comparison with my figures and those of Sheldon shows all the figures lying between them. This indicates that my figures were on the safe side, those of Sheldon on the higher side, except the figures for 1 and 2 mm. Al., which appear pretty high, as compared with unfiltered and higher filtered rays.

In order to determine the proper ratio between the unfiltered and mildly aluminum filtered radiations, I conducted the following experiment: 23 students of the College of Medicine and several assistants and doctors of the Research and Educational Hospital were exposed to the following three qualities of rays:

(1) 6 in. gap, no filter.
(2) 8 in. gap, 2 mm. Al.
(3) 10 in. gap, 4 mm. Al.

The exposures were given with a universal tube, at 5 ma., 8 in. F.S.D., 80 seconds to 7 minutes treatment time, and with a water-cooled deep therapy tube, at 30 ma., 12 in. F.S.D., and 1 to 4 minutes treatment time. The three qualities were applied to the left lower arm of each person, close together on an area which was partly, but not too densely, covered by hair, sometimes closer to the flexor, sometimes to the extensor side. The reactions produced were compared by an apparatus constructed for this purpose on the following principle: A small skin area was illuminated by an incandescent lamp which was hidden to the eye. The area could be observed by the eye, with various filters alternately inserted. These filters were made by staining a celluloid film in a mixed solution of Bismarck brown and eosin to a resulting tan similar to an average erythema. The filters were combined of from one to seven of those films. The apparatus was operated by inserting a filter of a sufficient number of thicknesses so that the limit between the normal skin and the irradiated area disappeared. A quantitative estimation of the

erythema could be attained this way, in an arbitrary scale.

The results are given in the sixth column of the chart, for both tubes. The output of these tubes differs widely for unfiltered rays, probably due to the thicker glass of the water-cooled deep therapy tube; this accounts for the different figures, as 3.3 and 6.5. With higher voltage and filter this difference gradually disappears, as the figures 22 and 23, and 55 indicate. These figures range again between my figures and those of Sheldon, indicating that on the average the treatments given with 2 (and probably with 1) mm. are too high, as compared with unfiltered and higher filtered conditions.

By the employment of all these experimental data the factor "K" was pretty well determined for erythema doses and varying filters. I have tried to express this factor by a formula rather than by an empirical chart. The closest approximation that can be reached by simple arithmetical means is given by the expression $K = (n + 2\frac{1}{2})^2$, in which "n" is the millimeter thickness of aluminum. Without the filter, this expression is $(2\frac{1}{2})^2$, or $6\frac{1}{4}$, or approximately 6; for 1 mm. Al. it is $(3\frac{1}{2})^2$, or about 12, etc.

These figures are given in the seventh column of the chart. This column can even be extended for copper filters, if the equivalent aluminum thickness is used. In our case this equivalence is given by

1/4 mm. Cu. + 1 mm. Al.... 8 mm. Al....K=$(10\frac{1}{2})^2$,
2/4 mm. Cu. + 1 mm. Al....10 mm. Al....K=$(12\frac{1}{2})^2$,
3/4 mm. Cu. + 1 mm. Al....12 mm. Al....K=$(14\frac{1}{2})^2$,
4/4 mm. Cu. + 1 mm. Al....14 mm. Al....K=$(16\frac{1}{2})^2$.

According to these results we can now express our formula

$$t = \frac{\text{F.S.D.}^2 \times (n + 2\frac{1}{2})^2}{\text{spark gap}^2 \times \text{ma.}}$$

As it is difficult to figure the square of $2\frac{1}{2}$, $3\frac{1}{2}$, etc., it is simpler to replace the parenthesis by one that gives practically the same result $(n + 2) \times (n + 3)$. The formula finally reads then:

$$t = \frac{\text{F.S.D.}^2 \times (n + 2) \times (n + 3)}{\text{spark gap}^2 \times \text{ma.}}$$

("t" in minutes, "n" in mm., F.S.D. and spark gap in centimeters or inches, both in the same unit, however).

One can use this formula for figuring out his treatment time for practically every treatment condition. If one wishes to know his erythema time for 8 inch gap, 5 ma., 3 mm. Al., 10 inch F.S.D., he figures

$$t = \frac{10.10 \times (3+2) \times (3+3)}{8 \times 8 \times 5} = \frac{10 \times 10 \times 5 \times 6}{8 \times 8 \times 5} =$$

9 to 10 minutes.

It should be kept in mind, however, that the given figures represent actual erythema doses, and that it is not desired commonly to apply those doses. This holds true particularly for skin work, especially on the face and other exposed parts of the body. In this case about 30 per cent less exposure should be given, and the treatment is mostly applied in interrupted dosage. To be safe, one can use the formula:

$$t = \frac{\text{F.S.D.}^2 \times (n + 2)^2}{\text{sp. gp.}^2 \times \text{ma.}}$$

which gives somewhat lower figures, especially for unfiltered work. The corresponding figures are given in the eighth column of the chart.

This formula can also be used for comparing treatment conditions. In the literature the dosage is mostly expressed merely by the electrical and mechanical factors. In order to estimate the applied dosage from these data it is best to figure the product

$$\frac{\text{sp. gp.}^2 \times \text{ma.} \times t}{\text{F.S.D.}^2 \times (n+2) \times (n+3)}$$

If this expression turns out to be 1, it signifies an erythema dose, and each resulting figure will represent the fraction or multiple of an erythema dose.

Suppose that a 10 inch gap, 5 ma., ½ mm. Cu. (equivalent 10 mm. Al.), 20 inch F.S.D. 100 minutes were applied, then:

$$\frac{10\times10\times5\times100}{20\times20\times(10+2)\times(10+3)}=\frac{10\times10\times5\times100}{20\times20\times12.13}=0.8$$

This means that 80 per cent of an erythema dose has been applied.

In introducing this formula I should like to ask you to give it a practical trial. It is based upon empirical observation and the statistical use of the treatment conditions in this country. It is simple, but of a very general usefulness, and therefore I hope it will be favorably accepted. On the other hand, you cannot expect too much of such a simple formula. It does not take into account the variation of the output of an X-ray tube, which depends upon many electrical and mechanical factors. It does not consider the site of the port of entry, which partly determines the biological effect. It does not exactly correspond to the effect of the voltage, insofar as the intensity is not exactly in ratio to the square of the spark gap. Particularly for no or weak filtration this law does not hold true. Also, the filter effect is different for different voltages. The formula therefore uses averages of practical treatment conditions.

In this connection I come to the second method of determining dosage, which I have tried to improve. It is the direct measurement of the produced radiation, without much attention to the conditions which produce the radiation. Directly after the *R* unit had been established, which is widely used now, I had standardized my electroscope in this unit by my own measurements. I had the electroscope of the College of Medicine compared also with the original unit, which is kept in the German Bureau of Standards. This proved to be of prime importance, as in the meantime many erythema doses have been determined, expressed by this unit.

(A communication with Glasser revealed that my *R* unit conforms within less than 10 per cent with the *R* determinations of Glasser and of Duane. The *R* unit of the German Bureau of Standards is much larger; the reason of the discrepancy is not yet known.)

The first measurements were made by Grebe and Martius, who determined the *R* units applied in 14 German universities in deep therapy work. This work was extended by Gruhn (7), Glasser (8) and others for superficial unfiltered and lightly filtered rays. I have also compared the applied energy in *R* units with the reactions produced, for five qualities of rays, one unfiltered, two aluminum filtered and two copper filtered radiations. Twenty-three students and several patients received measured doses of these radiations. The reactions were compared by the method described above. The results are given in Chart II.

In the first five columns the voltage, spark gap, filter, half value water thickness, and wave length are given, as measured by the authors, or as estimated by me. The sixth column gives the applied primary energy in *R* units, representing an erythema dose, in 14 German universities, as measured by Martius and Grebe. The seventh column gives the figures of Gruhn for three various qualities. The eighth gives Glasser's values for eight qualities. The ninth column gives the results of my quantitative measurements. The same results are given in German *R* units in the last column, for comparison with Columns 6 and 7. Except the figures of Martius and Grebe, they all show a marked increase of the dosage with shorter wave length, in each column the ratio 1:2 being approached for the radiations with lowest and highest penetration. This indicates clearly the greater sensitiveness of the tissue toward the softer rays, a fact which is even more pronounced when the secondary radiation of the tissue is included, which yields a larger increase

CHART II

K.V.	Spark gap (inches)	Filter (mm.)	Half value cm. H_2O	λ A. U.	R prim.				
					Grebe and Martius in German Units	Gruhn in German Units	Glasser in own units	Bachem in own units	Bachem in German units
75		0	1.2	(.6)			560		
100		0	1.5	.43			450		
100	6	0		.43				360	(225)
130		0	1.8	.40			400		
110	7	½ Al.			485				
160		1 Al.				260			
120	8	2 Al.		.3				385	(240)
130		2.5 Al.	2.5	(.3)			540		
130		4.5 Al.	2.8	(.25)			610		
140	10	4 Al.		.24				465	(300)
160		3 Al.				360			
130		¼ Cu.	3.2	.22			690		
130		½ Cu.	3.7	.18			800		
170	12	¼ Cu.		.17				585	(390)
170		½ Zn.			820				
170		½ Cu.			720				
185	15	½ Cu.			305				
185		½ Cu.			365				
185		½ Zn.			435				
(190)	15	½ Zn.			285				
(200)	14	½ Cu.			610				
200		½ Zn.				470			
(210)	15	½ Zn.			447				
200	14	¾ Cu.		.14				750	(500)
215		¾ Cu.	4.1	.14			900		
176		.8 Cu.			405				
210		.8 Cu.			800				
220		.8 Cu.			370				
240		½ Zn.			660				
(250)	19	½ Zn.			505				
180		1 Cu.			435				
170		1 Cu.			1050				
195		1 Zn.			435				
200		1 Cu.			435				
(250)	19	1 Zn.			570				
210		1.3 Cu.			375				
220		1.3 Cu.			390				

with harder than with softer rays, thus still increasing the ratio of the *R* figures.

As far as the absolute values are concerned, the sixth, seventh, and tenth columns are based upon the same (German) unit; the eighth and ninth columns become comparable if one subtracts about 10 per cent from Glasser's figures. With this in mind, one can see that my erythema doses agree very closely with those of Gruhn, and with the milder German doses as measured by Grebe and Martius. Glasser's erythema doses are a trifle higher and may compare with the average German doses.

I have tried to establish the biological reactions for smaller and larger applied energies. For this purpose I have exposed fifteen students to a varying dose of unfiltered rays. About ½, 1, and 1½ of my erythema dose, namely, 200, 400, and 600 *R*, was applied to the left forearm. The reactions were measured quantitatively with

the erythemameter mentioned previously. The time when the pre-reaction was first noticeable was measured also. The results are shown in Chart III.

blond and dark, strongly haired and practically non-haired subjects.

There occurred, however, two cases of a marked hypersensitivity: Subject 2, with

CHART III

Student	First appearance of pre-reaction after—hours			Average reaction for two months after treatment			Epilation with 600 *R*	
	200 *R*	400 *R*	600 *R*	200 *R*	400 *R*	600 *R*		
1	....	5	5	1	2	3	2	
2	6	4	4	5 (!)	6 (!)	7 (!)	2	Heart disease
3	5	5	5	0	1	3	1	
4	12	6	5	0	1	3	2	
5	7½	5½	4½	1	3	5	1	
6	....	9	8	0	1	3	2	
7	7½	6	5	1	3	5	1	
8	....	10	6	1	3	5	1	ascaris infection
9	....	8½	8½	0	0	2	1	
10	....	6	5	1	3	5	1	ex. T. B.
11	....	9	6	0	0	2	1	
12	6	3	3	1	2	4	0	
13	4	4	3	0	1	2	1	
14	6	5	4	0	2	3	1	
15	10	10	4	0	2	3 (blister!)	2	

These figures indicate that with the lowest energy used (½ E.D., or 200 *R*) no tanning or pigmentation followed in most of the cases. With the medium energy (1 E.D., or 400 *R*) all except two subjects showed a tanning and pigmentation. With the maximum dose (1½ E.D., or 600 *R*) all subjects had a marked reaction. In practically every case a preliminary erythema occurred, even in most individuals exposed to the lowest energy. The appearance time of this reaction varied between 3 to 12 hours, and depended somewhat, though not very pronouncedly, upon the applied energy. The strength of the final erythema, however, varied greatly with the applied energy; the average reaction was 1— for ½ E.D., 2+ for 1 E.D., and 4½ for 1½ E.D. Most of the subjects showed very little variation from the average reaction. It was really astonishing to see the same reaction taking place in a pronounced reaction even after ½ E.D. and an extremely pronounced reaction with the larger doses, and Subject 15, who developed a blister after several weeks which healed after about two months. Several of the subjects with stronger reaction showed signs of disease, as given in the last column.

The most spectacular case of hypersensitivity occurred in the group of twenty-three students who received an erythema dose of three qualities of rays. While the average reaction in this class was 2, one student reacted with 8 for unfiltered rays, 6 for 2 mm. Al., 7 for 4 mm. Al. Filtered rays even affected the skin at the opposite side through tissue and bone, causing reaction 1 and 3 with 2 and 4 mm., respectively. This student had active tuberculosis. Three students in this class were sensitive only slightly to the applied doses, showing practically no reactions.

In the group of fifteen students, most of them showed a partial epilation (1). The hair did not fall spontaneously, but could easily be removed by pulling. Five students had spontaneous temporary epilation (2) and in one case there was no sign of epilation at all (0). With lower doses, epilation was very incomplete (1).

In all these experiments I could observe that the reaction is by no means constant over a course of weeks. It goes up and down in certain cycles. This behavior has been extensively studied by Miescher (9), who first called attention to the regularity of the pre-reaction, and to two or three distinguishable waves which constitute the erythema. As these observations require a painstaking study, I observed them on my own body: 450 *R*, unfiltered rays, 300 *R*, filtered with 2 mm. and 4 mm. Al., respectively, were applied to my arm. The mildest reactions occurred with 300 *R* of 4 mm. filtered rays. The pre-reaction appeared about 6 hours after treatment, was scarcely detectable, and lasted for about a day. For the following three days nothing was noticeable; on the fifth day a second wave came, with a maximum intensity on the seventh day, then disappeared on the sixteenth day. A third wave, on the twenty-first day, I.=1, lasted to the forty-sixth day.

With 300 *R*, 2 mm. Al. filter, the pre-reaction came after five hours, lasting one day. After an interval of three days, on the fifth day, came the second wave, reaching its maximum on the twelfth day and its minimum on the twentieh day, and a third wave, with the maximum on the forty-first day, disappearing after the fiftieth day. The second and third waves were not separated, but a minimum occurred where they overlapped.

Similarly, with 300 *R*, unfiltered, the first wave appeared after five hours and lasted 2 days. After a 1-day interval, on the fourth day, the second wave appeared and lasted until the sixtieth day, up to Intensity 7, with a minimum near the nineteenth day.

In these experiments the intensity figures represent the total of tanning and pigmentation; a distinction between both reactions was not tried.

In regard to the strength and regularity of the pre-reaction, it is strange that more attention has not been called to them. I therefore conducted an experiment in order to determine the important factors which cause the pre-reaction. A voluntary laboratory assistant received 400 *R* unfiltered rays, once in 1 minute, once in $10 \times 1/10$ minutes, scattered over 10 minutes, once in $3 \times 1/3$ minutes, scattered over 3 days. In the first case the pre-reaction appeared with Intensity 3; in the second it showed up less (Intensity 2); in the third case there was no pre-reaction at all. On the fifth day, however, when the second wave in the first and second cases showed up with Intensities 3 and 2, a very mild tanning was detectable. After three weeks the three reactions were 3+, 3, and 2.

This experiment proves that the pre-reaction is determined to a marked degree by the concentration of energy. Interrupted dosage depresses the reaction remarkably. Much accumulation does not occur.

Finally, in collaboration with William F. Petersen, I have started an investigation to determine the biological factors which are responsible for differences of skin reactions. It is evident that this reaction depends upon the general vegetative status of the organism, which is determined by the autonomous system, internal secretion, ionic conditions, etc. In preliminary studies we have been able to establish a relationship between the permeability and the X-ray sensitivity of the skin. The permeability is determined by the time it takes to form a blister after cantharides plaster, and by the ratio of the protein in the blister to that in

the blood. From these data an inflammatory index was derived by dividing the second figure by the first one. A comparison of this index with the X-ray sensitivity showed an increase of the sensitivity toward X-ray, with an increase of the inflammatory index. As a close relationship exists between permeability and conductivity, we prepared an analogous investigation about the latter. We finally have detected a relationship to the potassium-calcium metabolism insofar as the sensitivity is low with a large $\frac{K}{CA}$ ratio in the serum. Under this condition the $\frac{K}{CA}$ ratio in the tissue is probably low, and the comparatively strong CA level in the tissue seems to account for the low sensitivity. There are more experiments planned which may lead to a control or a predetermination of the skin sensitivity.

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DISCUSSION

Dr. R. S. Landauer (Chicago): Dr. Bachem called attention to some of the errors in the formula which he gave, and I want to emphasize one of them in particular. The formula does not show at all the error due to variations in the output of X-ray tubes. In measurement over the last two or three years, I have found that for unfiltered rays and rays filtered through as much as a half-millimeter of copper, there are variations anywhere up to 50 per cent in the output of the tubes. It seems to me that it is too great an error to be uncounted. Since it is impossible to take tube variation into account in such a formula as Dr. Bachem presents, the latter must be used with the greatest caution.

Dr. Otto Glasser (New York): I agree with Dr. Bachem on many points, but I hardly can agree with him on the use of an arithmetic dosage formula for the determination of the initial roentgen dosage. With the X-ray machines we have at our disposal to-day, it is not yet possible to use any of the dosage formulæ proposed to calculate the initial dose. Last year, at the Cleveland meeting, we presented a table with the calibration data on 70 X-ray machines; since then 40 more machines have been added. The data obtained show that when measuring different machines and different tubes, there may be differences up to 200 per cent in the output, even though the same spark gap, the same milliamperage, and the same focal distance are used throughout. If such differences in the output are encountered, it must be admitted that it is not yet possible to use a formula for the calculation of the dose. However, after the dose for certain conditions is once known, it may be entirely possible to use such formulæ to calculate the dose for other conditions, providing these formulæ are in

agreement with well established physical laws.

There are many other points in Dr. Bachem's paper that I consider most valuable; I especially agree with him on his dosage determinations in electrostatic units. I had the opportunity to compare Dr. Bachem's dosage units with ours in Dr. Bachem's laboratory, and found that the two units agree well between themselves as well as with Dr. Duane's unit. They do not, however, agree at present with the German *R*-unit. For the time being, we ought to keep the unit upon which we agree in this country and which we are using with good success, until a unit is found upon which there is an international agreement.

Dr. Bachem (closing): As a physicist, I would prefer to see radiologists make exact measurements in order to determine the output of the X-ray installation and their erythema dose. Generally, this is not done. A small percentage of radiologists both in superficial and deep therapy work use measuring instruments. In most cases in modern work and in the literature the electrical and mechanical factors are given, but nothing else. Yet in all these cases we have to come to some approximate estimation, as to what doses have been applied. These are the reasons why various authors have introduced formulæ. These formulæ, however, are not based on accurate physical conditions and do not give the proper relationship between unfiltered and filtered rays. I have published several articles about this to which I must refer you for details. Sheldon's formula can not be used for unfiltered rays, because the treatment time comes out as zero. With the filtered rays, it comes out better, but rather high. The formula of MacKee and Witherbee can not be used for comparison of unfiltered and filtered rays: it gives a smaller treatment time for rays filtered through thin aluminum than for unfiltered rays. For these reasons I introduced a formula which is based upon correct physical principles and upon an immense amount of empirical material. I have myself outlined the limitations of this formula, and everyone who uses it has to consider the possibility that he may be off a certain percentage to one side or the other. Should one wish to apply an exact dosage, one must make exact measurements, with a standardized instrument, or consult a physicist.

EDITORIAL

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THE SERVICE OF X-RAYS IN PUBLIC HEALTH[1]

In a general way, it can be said that public health work is theoretically divisible into two parts—curative medicine and preventive medicine. Under the phrase "curative medicine" I would include all of the procedures by which we may cure an individual or a community of its ills. Preventive medicine—and this may seem like a paradox to you—includes curative medicine and all medical, surgical, and sanitary practices by which the individual, the group, or the community is preserved from the ills of the mind and flesh that might otherwise afflict it. I include curative medicine as a major branch of preventive medicine in this sense. To use only a single illustration, every case of diphtheria that is brought to termination by a physician, is one more case that is the more quickly eliminated from the number of foci of infection for the susceptible population.

Inasmuch as X-rays make possible certain types of diagnoses that are otherwise impossible, and for many groups of pathological conditions make for an accuracy that is on a par with autopsy technic, the importance of the radiologist in curative and in preventive medicine is plain.

One of the starting points in the proper administration of a health department is the collection of an accurate body of statistics on deaths and their causes. Without knowledge of how many deaths are occurring in the community, in which seasons of the year, among which racial, nativity, age, or sex groups, and, particularly, from what causes, public health administration is little more than the back-yard sanitation of our professional ancestors. We have reasonably complete reporting of deaths in most of the United States. Further, most of the statements that appear on a death certificate are given with reasonable precision. But the statements of the primary causes of death, taken by and large, are still woefully inaccurate.

From the well-known work of Dr. Cabot, Dr. Emerson and others, it is safe to conclude that about 5 per cent of the statements of cause of death cannot be accepted without autopsy; about 50 per cent are acceptable if supporting data are available, and the remaining 45 per cent are probably reliable. It is plain where the radiologist comes in. Upon him must fall one of the primary burdens for improving the accuracy of the diagnoses of causes of sickness and of death. The radiologist must work during the lifetime of the individual as the autopsy pathologist does after death has safeguarded him from the "slings and arrows of outrageous fortune."

To illustrate the type of uncertainty in administrative practice that comes from the questionable status of diagnostic technic, consider the situation with respect to cancer. Anybody can show that the death rates for cancer, as calculated from reported deaths, are increasing. But you all know how much difference of opinion there is as

[1]Dr. Bundesen is Commissioner of Health of Chicago. This address was read for him by Dr. I. S. Falk, at the Twelfth Annual Meeting of the Radiological Society of North America, at Milwaukee, Dec. 3, 1926.

to the interpretation that is to be placed upon these figures. The debates among statisticians, pathologists, physicians and others started about thirty-five years ago and we are no nearer a solution to-day. The fact that the increase in the general cancer death rate is largely due to increases in the specific death rates from the cancers of inaccessible portions of the body has been one of the strongest objections to acceptance of cancer statistics at their face value. It is my opinion that improved diagnostic methods—especially improved X-ray technic—are largely to blame for the apparent increases in cancer mortality. I am tempted to say that it is the X-ray experts who have gotten us into the cancer mess and it is up to them to get us out by further improving the service they render in increasing the accuracy of diagnoses.

X-ray diagnosis has already an illustrious record behind it for its services to medical practice in detecting the incipient case of tuberculosis. In our modern anti-tuberculosis program, roentgen-ray technic is one of the very starting points. The recognition of the early case and the isolation to a sanatorium for care and supervision and treatment, have probably done more towards the attainment of the present low mortality from tuberculosis than any other single program of recent years.

The service of the X-rays in preventive as well as in curative dental surgery has been a public health development on a par with the infant welfare program. The control of infant mortality is probably approaching its summit; but the service of radiology in dentistry and other practices in the alleviation of pain and in the elimination and prevention of focal infections, in spite of its tremendous development, I venture to say is still only in its infancy. In general medicine, in surgery and in other branches,—when the diagnostic aids of the X-ray are as common and as regular as percussion, the use of the stethoscope, the sphygmomanometer, or the technic of urine analysis,—then will the radiologist have come into his own.

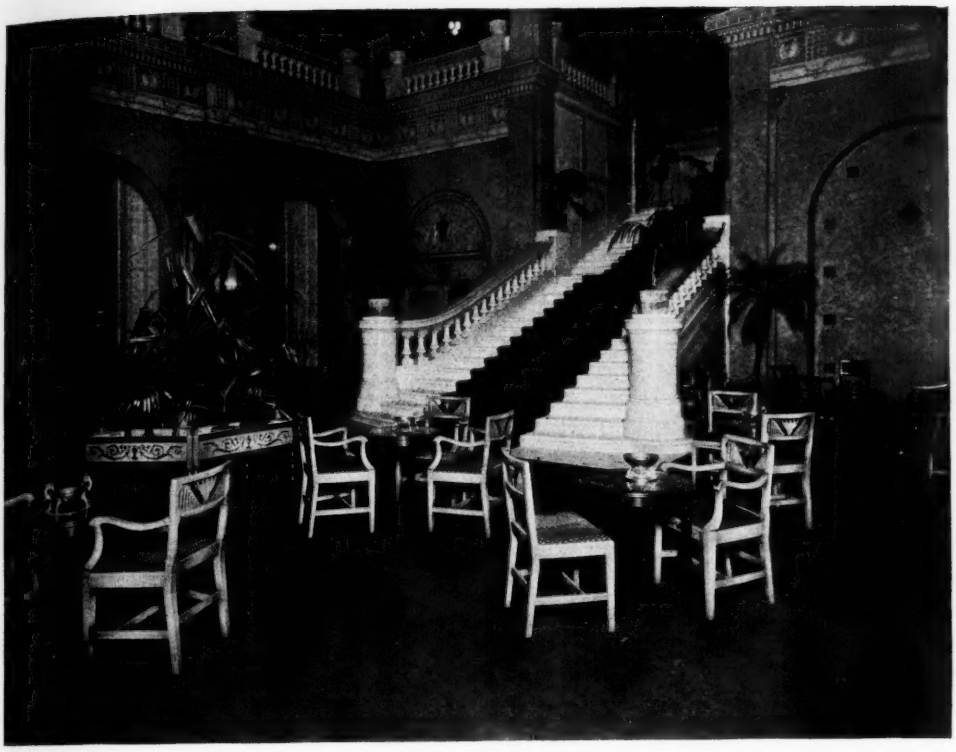
At this writing, I have before me a copy of the new Schlesinger's "Röntgendiagnostik," and I am overwhelmed at the perfection of the technic in the diagnostics for the diseases of the alimentary tract.

The recent developments of X-ray diagnosis in the periodic examinations of supposedly healthy persons have opened a new path for medical and public health development. And the increasing use of X-rays as therapeutic agents, as in the recent developments in the treatment of whooping cough, promises a glorious future for these vibrations of the now nearly defunct ether.

Finally, in closing let me say the proverbial "one word more" for the romance of X-rays. It is said that Röntgen made his discovery because he had the bad habit of using a key for a book-mark. To-day, research in the physics of atomic and vibratory phenomena is going at an unprecedented rate. The recent announcement of the marvelous developments of the Coolidge tube holds promise for the future that even you and I cannot see. Along which path new discoveries will go, no man can tell. But anyone who has an imagination can see that the obscure and abstruse physics and chemistry of to-day are but the foundation of the technic that diagnosticians will tacitly accept in the future.

If only we safeguard our X-rays and other rays from exploitation by the charlatan, we shall see expansions in the service of man that will justify even the irritating abstruseness of Einstein.

HERMAN N. BUNDESEN, M.D.



The Palm Room, Hotel Roosevelt, New Orleans. Here, and in the adjoining Venetian Room, the exhibits will be shown.

MATTERS OF INTEREST CONCERNING THE ANNUAL MEETING

The Program Committee has decided unanimously to reduce the number of days to four and one-half, beginning Monday noon and running until Friday evening. The Scientific Sessions will be cut one-half hour in the forenoon and a full hour in the afternoon, in order to give the members an opportunity to attend the clinics, to study the scientific exhibit, to visit the commercial exhibit, and to spend a little more time in fraternizing.

Two foreign guests have already accepted our invitation to be with us and to take part in the program. They are Professor H. Holthusen, Hamburg, Germany, and Dr. Anton Lacassagne, Curie Institute, Paris. It is possible that one or two others to whom we have issued invitations will be with us.

In the Scientific Sessions we are trying to have all that is new in roentgenology, as well as papers which will bring the old material up to date.

Dr. Cole is arranging a round-table discussion with the idea of a debate between physicians who have different opinions on some well known subject. His subject will probably be "Gastric Ulcer."

Dr. Case is trying out a new idea. He is arranging a scientific session in which we hope to have the subject matter presented only in abstract form or with lantern slides. This will enable a larger number of men

to participate and also save much repetition. His subject will be "Diseases of the Biliary Passages."

The clinics this year will be presented by the profession of New Orleans and other members of the Society. Dr. Sante is in charge of the Master Clinics. He hopes to have every day a series of clinics running on different subjects of interest, by men who are prominent as teachers and in research work. This feature has been attempted before but we hope to enlarge it at the next session.

The scientific exhibit should be better than ever. We are making an effort to secure a great number of transparencies and films from our own membership. We expect that the Society Library will be large enough to make a good showing.

Responses from the various commercial houses interested in X-ray equipment show that there will be an unusually interesting display of X-ray equipment, accessories, and supplies.

The program is coming in rapidly and in a short time it will be full. We will try to accept the most interesting papers—whenever there is a real message for the membership.

EDWARD W. ROWE, M.D.,
President.

NEW ORLEANS HOTELS

For those expecting to attend the Annual Meeting of the Radiological Society in New Orleans from Monday, November 28, to Saturday, December 3, the following information concerning hotel rates has been supplied by the Local Committee.

The Roosevelt, 123 Baronne Street, is the headquarters hotel and in it the sessions and exhibits will be held.

Single room,
with bath.....$5.00 and $6.00 per day.
Double room,
with bath.....$7.00 and $8.00 per day.
Most desirable twin-bedded front rooms,
with bath.....$10.00 per day.

The Bienville, St. Charles Avenue and the Lee Circle, is owned and operated by the management of the Roosevelt.

Single room,
with bath.....$4.00 and $5.00 per day.
Double room,
with bath.....$6.00 and $7.00 per day.
Most desirable twin-bedded rooms,
with bath.....$8.00 per day.

De Soto Hotel, 420 Baronne Street.

Single room,
with bath.....$4.00 per day.
Double room,
with bath.....$6.00 per day.
Double room, twin beds,
with bath.....$7.00 per day.
Single room,
without bath.....$3.00 per day.
Double room,
without bath.....$5.00 per day.

Jung Hotel, 1500 Canal Street.

Single room,
with bath.....$3.00, $3.50, and $4.00 per day.
Double room, double bed,
with bath.....$5.00 per day.
Double room, twin beds,
with bath.....$5.00 and $6.00 per day.

Lafayette Hotel, 628 St. Charles Street.

Single room,
with bath.....$3.50 and $4.00 per day.
Double room,
with bath.....$5.00 and $6.00 per day.
Double room, twin beds,
with bath.....$7.00 per day.
Single room,
without bath.....$2.50 and $3.00 per day.
Double room,
without bath.....$3.50 and $4.00 per day.

La Salle Hotel, 1113 Canal Street.

Single room,
with bath.....$3.00 and $3.50 per day
($1.00 extra for each additional guest).
Single room,
without bath.....$2.00 and $2.50 per day.

New Monteleone Hotel, 214 Royal Street.

Single room, with bath.....$3.00, $3.50, and $4.00 per day.
Double room, with bath.....$5.00 per day.
Double room, twin beds, with bath.....$6.00 and $7.00 per day.
Single room, without bath.....$2.00 and $2.50 per day.
Double room, without bath.....$3.50 and $4.00 per day.

All persons planning to attend will be more sure of securing the accommodations which they desire—both as to location and rate—if they make their reservations in advance.

SECOND INTERNATIONAL CONGRESS OF RADIOLOGY

STOCKHOLM, July 23-27, 1928

[We are glad to publish the following announcement, received from Dr. Gösta Forssell, and hope numerous members of the Society will enroll themselves as Members of the Congress.—*Editor.*]

The Second International Congress of Radiology will be held in Stockholm from July 23 to July 27, 1928.

The Congress will occupy itself with questions regarding Roentgendiagnostics, Radiotherapy (Roentgen-, Radium-, and Heliotherapy), Medical Electrology, Radiophysics, and Instruction and Training in Radiology.

Announcement of papers intended to be read at the Congress must be submitted before January 1, 1928. A *typewritten abstract of the paper,* in English, French, or German, of not more than 400 words, one (1) page octavo, must be sent to the Secretary-General before April 1, 1928. These summaries are intended to be printed and delivered to the members before the Congress.

If more papers are announced than can possibly be read, the Committee claims the right to limit their number in the interest of the Congress. Preference will be given to papers containing original work. Lecturers may not submit more than two papers. An address may not exceed fifteen minutes.

Those who desire to be enrolled as members of the Congress are requested to forward *as soon as possible the fee for membership* (40 Swedish Crowns), together with their names and addresses, in the following form (see below), to the Secretary-General, so that some estimate may be ascertained of the number of members attending, and arrangements made for their comfort and pleasure.

In connection with the Congress an *exhibition* will be arranged. Firms wishing to exhibit may obtain the necessary particulars and forms through the Secretary-General. Only those who have announced before October 1, 1927, their intention of participating, can be sure of obtaining space in the exhibition rooms.

Further particulars will be sent later. Only those who have already been enrolled as members can expect further communications.

All communications should be addressed to *the Secretary-General, International Con-*

SECOND INTERNATIONAL CONGRESS OF RADIOLOGY, 1928, STOCKHOLM, SWEDEN

I desire to be enrolled as a member of the Congress. The amount of my subscription (40 Swedish Crowns) is sent by p. o. o.
check

Name in full: .....

Title: .....

Address in full: .....

1927.

Checks and money orders payable to Internat. Congress of Radiology, Stockholm.

gress of Radiology, Sophiahemmet, Stockholm, Sweden.

GÖSTA FORSSELL, *President.*
AXEL RENANDER, *Secretary-General.*

THE DANGER OF IRRADIATING MILK[1]

In a letter to the *Times,* Dr. J. C. Drummond, Professor of Biochemistry at the University of London, sounds a word of warning in regard to the irradiation of milk by ultra-violet rays, to which it recently devoted a leading article. He admits that the nutritive value of certain foodstuffs, including milk, from the standpoint of their value in the prevention or treatment of rickets, can be considerably increased by exposure to the radiations of ultra-violet lamps by a change either in the cholesterol or in some closely related body. But it is insufficiently recognized by many who are interested in the practical application of these facts that the short wave length radiations of the ultra-violet part of the spectrum are extremely powerful agents. Milk which has been exposed to the radiations of a mercury vapor lamp for as short a time as five minutes not only becomes unpalatable, in that it acquires an unpleasant, tallowy odor, but suffers chemical changes highly undesirable from the standpoint of nutrition. Of these, one is the destruction of Vitamin A by oxidation. In Germany, and, to a less extent, in this country [England], the treatment of rachitic children is being carried out with irradiated milk. If the irradiated milk forms the chief part of their food, the children will receive an inadequate supply of Vitamin A, and may therefore show the retarded growth and lowered resistance due to insufficiency of this substance in the dietary. If the irradiated milk is being employed medicinally as an antirachitic, it is hard to understand why it should be used in preference to the more potent and not much more unpalatable cod liver oil. A number of other foodstuffs might be used after irradiation as sources of the antirachitic vitamin that do not appear to suffer deleterious changes during the treatment with the light. Thus, many of the vegetable oils contain the precursor of the antirachitic vitamin, but little, if any, Vitamin A. Such oils, after irradiation, are antirachitic; they remain relatively palatable, and might be used medicinally in cases in which cod liver oil is not well tolerated. The tendency to apply somewhat generally the results of laboratory research before they are ripe for practical use is to be regretted, and considerable experimental work remains to be carried out before the conditions have been determined under which so labile and complex a foodstuff as milk can be subjected to the powerful action of ultra-violet or other irradiation without serious impairment of nutritive value. A more promising line of investigation, and one along which considerable progress has already been made, consists in researches, carried out at the national institute for research in dairying at Reading University [England], on the problem of so feeding dairy herds that the milk yielded will show a high vitamin value throughout the year.

[1]Reprinted by permission from the *Journal of the American Medical Association,* March 26, 1927, p. 1014.

THE AMERICAN LEGION

Dr. Vignal has been appointed by the Association Amicale des anciens Medecins des Corps combattants as General Secretary of the Committee of Reception of the Medical Members of the American Legion who will be in Paris in September, 1927. He will be glad to know if any members of this Society are coming and how many; also, if they wish, besides their official program, to

see what is being done in Paris in roentgenotherapy and in curietherapy. If so, interesting visits to some of the Paris hospitals and to the Institute Curie can be arranged.

Dr. Vignal's address is 51 Rue de Lille: telephone Fleurus 21-51.

The Insurance Questionnaire

On June 10 a questionnaire relative to malpractice insurance was mailed to every member of the Radiological Society, with an urgent request that it be filled out and mailed to the Chairman of the Committee on Insurance immediately.

Up to the time of this writing (June 23), slightly less than one-third of these questionnaires have been sent in. It is to the interest of all radiologists that the information elicited by this questionnaire be collected and tabulated, and it is already evident that the data so collected are going to be of incalculable value to us in the very near future.

All who have not yet sent theirs in are urged to fill out and mail them *immediately. Do it now.*

DR. COOLIDGE HONORED

Dr. W. D. Coolidge, Assistant Director of the Research Laboratory of the General Electric Company, has been honored by the American College of Radiology and the Franklin Institute. Both honors, in the form of gold medals, were received the same day, May 18, one in the afternoon in Philadelphia and the other in the evening in Washington.

The award by the American College of Radiology was made "in recognition of his contribution to radiology and the science of medicine." At the same time this medal was presented, Dr. Coolidge was made a fellow of the College. This was the first award of the gold medal by the American College of Radiology. The other award, that by the Franklin Institute, was the Louis Edward Levy gold medal, for his paper read about a year ago on "The Production of High Voltage Cathode Rays Outside the Generating Tube."

BOOK REVIEWS

X-RAY DIAGNOSIS: A MANUAL FOR SURGEONS, PRACTITIONERS, AND STUDENTS, by J. MAGNUS REDDING, F.R.C.S., Senior Surgical Radiologist, Guy's Hospital, London. William Wood & Co., New York, 1927. Pages 228. Price $7.00.

In this work the author has endeavored to outline the guiding principles of radiographic diagnosis. With this in mind the descriptions of the lesions affecting the different anatomical systems are preceded in each instance by an analysis of the appearances produced by the normal structures and of the modifications in those appearances which result from disease.

The introductory chapter reflects much thought and the experienced radiographer as well as the tyro will find therein a refreshing reminder of the principles so essential to the proper pursuit of scientific roentgenology.

Seventy-five pages are devoted to a consideration of the various abnormalities of the skeletal system. These chapters are exceedingly well arranged and constitute one of the best general discussions obtainable on this subject.

The various other systems of the body are adequately discussed and the essential diag-

nostic points well elucidated. Here and there the more experienced individual will find a statement that will occasion a difference of opinion, but the few such instances do not greatly detract from the vast amount of information set forth. While the text contains frequent notations to the literature, it is to be regretted that the bibliography for a book of this sort has not been enlarged upon.

On the whole this work represents a worthy addition to the fundamental textbooks of roentgenology and should be read by all those interested in the scientific pursuit of this specialty.

INTERNATIONAL RADIOTHERAPY: REVIEWS IN THE FIELD OF ROENTGEN-, CURIE-, LIGHT-, AND ELECTRO-THERAPY (INTERNATIONALE RADIOTHERAPIE: BESPRECHUNGSWERK AUF DEM GEBIETE DER RÖNTGEN-, CURIE-, LICHT-, UND ELEKTROTHERAPIE). Under the Editorship of J. WETTERER, 1925-1926, I. Pages 1061. L. C. Wittich, Darmstadt, 1926.

This volume is made up in large part of abstracts of published papers on radiation therapy—physical and technical, biological effects, skin diseases, gynecologic diseases, malignancies, tuberculosis, internal medication, urologic diseases, venereal diseases, diseases of the gastro-intestinal tract, diseases of the sinuses, eyes, etc. The balance of the volume—some 250 pages—is made up of monographs on problems of technic and dosage, gamma-ray therapy, heliotherapy, treatment of skin cancer, dermatological lesions, development and progress of radiation therapy in various countries, and other related subjects, written by experts in the various fields.

Dr. Wetterer has made an admirable attempt—and seems to have met with a large measure of success in its accomplishment—to bring together and classify the rapidly accumulating literature on radiant energy and its application.

INTERNATIONAL CLINICS. A quarterly of illustrated clinical lectures and illustrated articles on treatment, medicine, neurology, pediatrics, obstetrics, gynecology, orthopedics, pathology, dermatology, ophthalmology, otology, rhinology, laryngology, hygiene and other topics of interest to students and practitioners. By leading members of the medical profession throughout the world. Volume 1, 37th series, 1927.

This volume of the International Clinics is an exceedingly instructive and useful one, the articles it contains being presented by men of international prominence and marked ability. The articles of especial interest are:

"Professor Barker's Medical Clinics," by Lewellys F. Barker, M.D., Johns Hopkins Medical School. Dr. Barker discusses the subject of diabetes mellitus with severe acidosis in a very interesting and instructive manner.

Richard Kovacs, M.D., discusses "The Technic of Medical Diathermy." Dr. Kovacs mentions very appropriately the tendency shown by many members of the medical profession to enter the field of physiotherapy: also the deplorable fact that these men have had no previous training in the fundamentals of electrotherapy, the prevalent idea being that a knowledge of the application of this form of therapy can be obtained easily in from a week to ten days' time.

Professor T. M. Van Leeuwen, M.D., University of Utrecht, Holland, contributes an article on "The Treatment of Gonorrhea by Diathermy." Professor Oswald Bumke, M.D., University of Munich, Germany, discusses "Problems of Paresis." Paul E. Bowers, M.D., M.S., strikes a rather pessi-

mistic note in discussing "Modern Social Conditions and the Venereal Disease Problem." A more optimistic atmosphere is given the subject in his concluding remarks relative to sex instruction to the young.

Percy B. Davidson, M.D., treats the subject of "Digestive Syndromes Encountered in Cardiovascular Disease" in a very interesting and efficient manner. René A. Gutmann, M.D., Paris, France, discusses "The Medical Treatment of Uncomplicated Gastric Ulcer" in a manner that should prove interesting and useful to the general practitioner. T. W. Grayson, M.D., Lieut.-Col. Med. Reserve, U. S. A., Pittsburgh, Pa., discusses "The Best Diet" in a comprehensive manner.

H. Van Wely, M.D., The Hague Hospital, Holland, discusses "The Action of Quinine and Quinidine upon the Heart." This chapter should prove interesting to the man doing general practice and also to the internist. F. Harbitz, M.D., Professor of Pathology, University of Oslo, Norway, discusses "Different Forms of Arteritis." Joseph Matti, M.D., Geneva, Switzerland, discusses "Malignant Endocarditis."

Charles Greene Cumston, M.D., contributes a short article on "Objective Medicine," which should prove illuminating to the general practitioner. Dean Lewis, M.D., contributes a treatise on clinical cases at Johns Hopkins Hospital. W. Wayne Babcock, M.D., F.A.C.S., Temple University, Philadelphia, is represented by a chapter on "Problem and Practice in Biliary Surgery." This contribution is well written and well illustrated and presents in a most interesting manner some advanced ideas in biliary surgery.

Brooke M. Anspach, M.D., Jefferson Medical College, Philadelphia, presents three cases of more than usual interest: "Chorio-epithelioma Following Hydatid Mole in a Primipara," "Acute Torsion of a Solid Tumor of the Left Ovary," and "Calculus Pyonephrosis Following Pregnancy." Professor Sauerbruch, M.D., University of Munich, Germany, contributes an article on "Thoracoplasty."

Dr. C. J. Drueck, M.D., F.A.C.S., Post-Graduate Hospital and Medical School, Chicago, discusses "Types of Anal and Rectal Cancer." Dr. Drueck covers the subject in a most interesting manner and this article should prove instructive reading for those engaged in this work.

Lieut.-Col. J. N. Phalen, M.D., Washington, D.C., contributes a short discussion of medical indices in the Quarterly Cumulative Index Medicus as an aid to the clinician and surgeon.

The remainder of the volume is devoted to the progress of medicine for 1926, collected by Henry W. Cattell, M.A., M.D., Philadelphia, and J. F. Coupal, M.D., Maj. M.C., U. S. A., Washington, D. C. This review is well worth reading as it furnishes a summary in a concise form of the outstanding features of medicine for the year 1926.

An interesting item from this progress of medicine is the Blair Bell treatment of cancer. This should be especially instructive to the radiologist. In the discussion of the Blair Bell treatment of cancer Francis C. Wood, M.D., gives first-hand information pertaining to the treatment of cancer by the use of hypodermic injections of colloidal lead. Dr. Wood states that it is his belief that colloidal lead therapy and radiotherapy can perhaps be combined advantageously.

In conclusion, it is my opinion that this volume of International Clinics provides useful and interesting material and should prove a valuable addition to the library, for both the general practitioner and specialist.

B. C. CUSHWAY, M.D.

ABSTRACTS OF CURRENT LITERATURE

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WYETH, GEORGE A. Newer Developments in Electrothermic Methods in the Treatment of Neoplasms 261

X-ray study of stomach.—The question of chronic diffuse thickening of the walls of the stomach has interested pathologists and surgeons for many years. Diffuse induration or hypertrophy may be general or may be confined to one portion of the stomach. Diffuse induration accompanied by a great diminution in the size of the stomach is generally known as linitis plastica, or "leather bottle stomach." This is recognizable by the roentgen ray. The more localized type is most often seen in the pyloric end of the stomach. The X-ray does not seem to be able to differentiate carcinoma, indurated peptic ulcer, or benign hypertrophy. Two cases of benign hypertrophy are reported in detail. The author quotes Goldschmidt that a sharp line should be drawn between the cases localized in the pylorus and those in which the entire stomach is involved. It is especially important to omit those cases which are hypertrophies of the pyloric musculature.

The author discusses the etiology of linitis plastica as syphilis, carcinoma, or fibromatosis. Brinton described the greatest change as lying in the submucosa—it was unusually thickened by the great increase in fibrous tissue, with atypical epithelioid cells. Connective tissue was found lying between the bundles of muscle cells in the muscularis. The disease has an insidious onset and ends in death.

C. G. SUTHERLAND, M.B. (TOR.)

Benign Hypertrophy of the Stomach and Linitis Plastica. Kirby Dwight. Ann. Surg., May, 1927, LXXXV, 683.

Duplication of renal pelves.—Grajewski and Eisen found five instances of renal pelvic duplication in 248 cases. All cases except one were unilateral. In no case was there more than two ureteral openings in the bladder. Of their five, one case was in a female and four in males. There were no symptoms other than weakness and sometimes backache and loss of weight.

ROBERT A. ARENS, M.D.

Renal Pelvic Duplication. Leo E. Grajewski and Paul Eisen. Urologic and Cutaneous Review, January, 1927, p. 46.

Exogen factors in late reactions.—In a number of cases showing late reaction after roentgen therapy, the ulceration could be traced as due to a mechanical irritation. One patient used a nail-brush, another used tincture of iodin on the treated area. This illustrates the value of educating both the general practitioner and patients regarding the possibilities of such a combination.

(In our department each patient receives a so-called "caution slip" following his first treatment, explaining in detail how to prevent irritation of the exposed area.—*Abstractor.)*

E. A. POHLE, M.D.

Influence of Exogen Factors on the Formation of Late Reactions. G. Steiner. Strahlentherapie, 1927, XXIV, 748.

Electrothermic methods.—This paper sets forth to describe the adaptation of some of the newer electrothermic measures to the eradication of malignant disease. Basal cell tumors should be destroyed and eradicated, since, if temporized with, they may go on to more extensive growth. Precancerous conditions such as warts, moles, nevi, pigmented areas, keratoses and angiomata should all be completely destroyed while in this stage. This can now be accomplished by the lighter dehydrating currents. The development of the endothermic knife has increased the usefulness of diathermic methods. As produced by the three element vacuum tube system, the true cutting current (a current of exceedingly high frequency) causes a molecular dissolution of the tissues. With the ordinary steel needle, which is the usual type of active electrode and which needs to be only lightly brought into contact with the skin, a clean-cut incision is made with a narrow line of coagulation on either side. This narrow line of coagulation is sufficient to seal off lymphatics as it cuts, and to cap sensory nerves. The incision permits of primary union. The nature of the incision tends to limit metastases and to minimize mechanical dissemination. This type of knife is very advantageous in taking sections for microscopic examination since it seals off the lymphatics. Extensive major operations can be carried out with this procedure—breast amputations, for instance—and the results have been most gratifying.

L. R. SANTE, M.D.

Newer Developments in Electrothermic Methods in the Treatment of Neoplasms. George A. Wyeth. Surg., Gynec. and Obst., January, 1927, p. 95.

The small ionization chamber and scattered radiation in water.—Continuing their experiments dealing with the investigations of a small ionization chamber independent of the wave length between 50 K.V. (unfiltered) and 200 K.V. (1.0 Cu.) (See this Journal February, 1927, p. 175), the authors compared their results with data taken from an aluminum chamber. They find that the aluminum chamber shows a dependence from the wave length entirely different from that of air. This can only be explained by the Compton effect. The study of this phenomenon in other elements of low atomic weight should lead to the construction of a small ionization chamber, the sensitivity of which runs parallel to that of the skin. When measuring the depth dose, it appears that the position of the chamber (on the surface, half submerged, fully submerged) influences the result very

little. The amount of the so-called back-scattering on the surface which increases with the penetration of the radiation decreases again when using potentials over 200 K.V. This is also due to the Compton effect; with decreasing wave length, the ratio between recoil electrons and scattered radiation shifts in favor of the first.

E. A. POHLE, M.D.

Regarding a Small Ionization Chamber Independent from the Wave Length and on the Measuring of Back-scattering in a Water Phantom. R. Glocker and E. Kaupp. Strahlentherapie, 1927, XXIV, 517.

Tumors of the intestinal tract.—Carcinoma was found in 37; tuberculosis in 7; chronic inflammation in 2, and lymphosarcoma in 1; one undetermined probably followed a phlegmon of the appendix. Other tumors occasionally found are cysts, gummas, lipomas, tuberculomas, papillomas, cholesteatomas, leiomyomas, and actinomycosis. Carcinoma of the intestinal tract occurs with greater frequency in the fore gut and the hind gut. The mid gut, extending from the second portion of the duodenum to the ileocecal valve, is relatively free from invasions. The small intestines were involved in only 2.5 per cent of a large series reported. The greatest proportion of these occurred in the second portion of the duodenum about the biliary papilla. Those portions of the gut forced to offer more resistance to fecal movements are subjected to a more constant irritation. This resistance is probably greatest at the ileocecal junction and at the rectal valves. Distant metastases to other viscera outside the colon were not discovered.

Tuberculosis occurs primarily as well as secondarily in the cecal region. The pathological differences are quite marked. Tuberculosis of the cecum is very common in patients with pulmonary involvement, necropsy records showing 70 to 90 per cent. Because of the abundant lymphoid tissue, the ileocecal region is involved in about 85 per cent. Pathologically there are two distinct types: (1) ulcerative; (2) hyperplastic. The ulcerative group is considered a secondary manifestation of a primary focus elsewhere: 25 per cent produce stricture or stenosis. Similar tubercles in the serosa produce a dense, adhesive peritonitis. Surgery is indicated in this group only when obstruction makes it imperative. The hyperplastic group is considered to be primary in origin. Surgical excision in this group frequently perfects a cure.

Lymphosarcoma is an extremely rare disease of the cecum. It does occur with more frequency in the small intestine and the rectum. The tumor is extremely rapid in growth and is not painful. Metastases occur early in the contiguous lymphatics and likewise in distant organs. The course is rapidly fatal.

C. G. SUTHERLAND, M.B. (TOR.)

Tumors of the Cecum: Discussion and Report of 48 Cases. John F. Erdmann and Harold E. Clark. Ann. Surg., May, 1927, LXXXV, 722.

Complications of pregnancy.—The essayist outlines three types of anuria complicating pregnancy and the puerperal state: (1) Complete suppression due to kidney degeneration, sometimes spoken of as "idiopathic anuria"; (2) suppression due to urinary calculus, and (3) that due to ureteral edema or pressure. Complete suppression of the first type may be due to an exacerbation of a chronic nephritis, chemical poisoning, usually mercury or phosphorus, or degenerative nephritis apparently due to a metabolic poison incident to pregnancy. Examples of each are quoted in case reports.

Suppression from impacted calculus is, of course, an incidental occurrence.

The third type of suppression, from some metabolic poison incident to pregnancy, is well illustrated by two cases.

In conclusion, the essayist wishes to call particular attention to chronic pelvic passive congestion in pregnancy resulting in ureteral edema, to point out the necessity for and to

show the usefulness of the cystoscope in the diagnosis and treatment.

L. R. SANTE, M.D.

Suppression of Urine in Connection with Pregnancy. John C. Hirst, II. Am. Jour. Obst. and Gynec., November, 1926, p. 673.

Cholecystitis.—The author gives evidence of the value of the cholecystogram in the diagnosis of cholecystitis in the early stages of the disease, when the inflammatory changes are not marked. A cholecystogram serves as infallible evidence corroboratively in cases where the usual definite symptoms referable to gall-bladder disease have been present. By the absence of a shadow (using tetraiodophenolphthalein) it reveals involvement of the gall bladder in those few cases which have escaped the usual definite symptoms. When tetraiodophenolphthalein is used intravenously, stones or pericholecystitis may be revealed; there may be no shadow at all, or a faint shadow which is gone at twenty-four hours. Normally when the dye is administered intravenously a shadow is present at four hours. The ability of the gall bladder to concentrate the dye is an important point in the diagnosis.

By a careful history and physical examination about 70 per cent of longstanding cases can be recognized. These can be recognized pathologically by extensive scars and a thickened gall bladder—most often with stomes. Cholecystography in these cases has been an infallible corroborative laboratory procedure.

Cholecystography is an index of physiologic function of the gall bladder and therefore cholecystitis can be detected long before marked gross changes have occurred in the gall bladder.

In 35 cases histories and symptoms were markedly indefinite—often duplicating gastric or duodenal ulcer, vague diffuse abdominal discomfort, etc. These cases, plus cholecystographic evidence of abnormality, were considered qualified for operation. In these cases there either were no shadows or they were delayed at four hours or absent or faint at twenty-four hours. In every case so diagnosed cholecystectomy resulted in complete relief of symptoms. Chronic hepatitis was constantly found associated with chronic cholecystitis, no matter how slight the latter might be.

ROBERT A. ARENS, M.D.

Chronic Cholecystitis: An Analysis of 100 Consecutive Cases Diagnosed with Cholecystography and Treated by Cholecystectomy in Which the End-results were Investigated. Isaac Y. Olch. Am. Jour. Med. Sci., March, 1927, p. 368.

Investigations of the so-called "borderline rays."—The author has carried out a series of physical tests with the tube mentioned in the abstract of the Bucky paper in an effort to define the quality of the radiation which Bucky suggests be named "borderline rays." Animal experiments and capillary microscopical studies on the human skin seem to indicate that there is no principal difference in the action of these long roentgen rays and the wave length in common use. No new name is therefore indicated.

E. A. POHLE, M.D.

Physical and Biological Investigations Regarding the So-called "Borderline Rays." G. Gabriel. Strahlentherapie, 1927, XXIV, 534.

Calcification of the kidney.—This condition is rather readily produced by ligation of either the renal artery or the ureter. In this case the deposits are usually calcium phosphate, while following disease they are calcium carbonate. The author has been able to demonstrate a calcium deposit in the kidney in forty hours after temporary ligation. Permanent ligations cause extensive calcification in a few days.

Calcification of the kidney is found in the following conditions: (1) papillæ in advanced age; (2) resorptive processes of the skeleton; (3) poisons such as mercury, phosphor-

us, etc.; (4) fibrous atrophied glomeruli or the so-called lime bodies of the cortex; (5) renal pyramids in variola; (6) in children, in catarrhal condition of the intestines and in scarlet fever; (7) in renal tuberculosis, (8) and, possibly, in postmortem changes.

The author reports a case of extensive calcification following intravenous injection of mercurochrome.

ROBERT A. ARENS, M.D.

Calcification of the Kidney. Winfield S. Pugh. Urologic and Cutaneous Review, April, 1927, p. 208.

Semilunar bone.—Dislocation of the semilunar bone is the third most frequent injury to the wrist bones. It is more rare than Colles' fracture or fracture of the scaphoid, but is much more important from the standpoint of permanent disability. Eight cases are reported in detail, with dislocations of varying lengths of time, together with the methods of treatment used and the ultimate results. The X-ray gives material aid in diagnosis and in planning methods of procedure for operation.

SUMMARY

The experience in the author's cases and in those recorded in the literature leads to the following conclusions:

(A) Simple Dislocation of the Semilunar.—(1) Reduction can usually be accomplished by manipulation within the first three or four days, and complete return of function can be expected. (2) In cases in which removal of bone is done within two or three weeks or in which there is mild neurospastic fixation, good function will result, but at least some permanent weakness will remain. (3) Open reduction under the same circumstances promises as good a return of function as removal. There is danger, however, of traumatic arthritis. (4) Untreated patients have from 25 to 75 per cent permanent disability. (5) Open reduction after several weeks or in cases in which neurospastic fixation is severe should not be attempted, even though in many instances it can be accomplished. Removal is better. (6) Removal in late cases, with severe fixation and degenerative changes, usually will relieve the pain to a considerable degree. Improvement in function is slight.

(B) Fractures of the Scaphoid.—(1) Severe traumatic arthritis is so likely to occur in these cases that closed or open reduction is dangerous. If not accomplished within a few hours after injury, excision is therefore indicated. (2) Removal of semilunar and whole scaphoid bone seems to give as good results as those secured in cases in which the proximal fragment only is removed, and is the method of choice.

L. R. SANTE, M.D.

Dislocation of the Semilunar Bone: Neurospastic Fixation of the Hand: A Deformity Characteristic of the Injury. Earl D. McBride. Archiv. Surg., February, 1927, p. 584.

Variation in sensibility of tumors.—The two outstanding facts brought out by the clinical treatment of tumors by radiation are, first, that there are wide differences in the sensibility of tumors of different kinds, and, second, that the sensibility of tumors of the same kind in different patients also varies, though the latter variations are less wide.

The first kind of variation has been considered to reside in the tumor cells, and the second in the patient, and has been assumed to be due to a resistance towards tumor growth which varies from patient to patient.

In order to give a more certain explanation of these two most important clinical facts a series of experiments were carried out using mouse sarcoma, and demonstrating the influence of the host on sensibility to radiation, with the following conclusions:

1. That tumors left for four to five days in the animal after radiation and then removed and grafted into other animals, succumb more easily than when removed immediately after exposure.

2. The effect is associated with an interference with the blood supply which occurs four to five days after the exposure.

3. These results suggest the hypothesis

that the varying sensibility to radiation of tumors of the same kind, and the difference in sensibility between normal tissues and tumors, are associated with the variations in blood supply, on which the radiation has a special action, apart from its direct action on cells.

H. W. D. MACKENZIE, M.D.

Experiments on the Radiation of Tumors, with Special Reference to Their Blood Supply. J. C. Mottram. Brit. Med. Jour., Feb. 12, 1927, No. 3449, p. 275.

Statistics of diaphragmatic hernia.—In a series of four hundred cases reviewed by Hedblom, which included all to 1924, only six were in children under five years of age. The author reports one case; the patient was operated on and died.

C. G. SUTHERLAND, M.B. (TOR.)

Non-traumatic Diaphragmatic Hernia. Jerome S. Leopold. Am. Jour. Dis. Child., April, 1927, p. 597.

Roentgen-ray treatment of erysipelas.—The authors take up the various forms of treatment used for erysipelas and then give the literature regarding roentgen-ray treatments. They report treating eleven patients with the following technic: Area involved and a 5 cm. border, using unfiltered radiation at 100 K.V., 50 cm. distant and 35 ma. minutes over each area. Irradiation is repeated in two days if the regression has not been satisfactory. A third treatment was administered to one patient with only a first degree erythema.

The authors' conclusions are: (1) Roentgen therapy for erysipelas is a valuable form of treatment; (2) relief is generally obtained within twenty-four hours; (3) the febrile period is shorter than in infections of equal severity treated by other measures and the usual length of illness is shortened; (4) there are, possibly, fewer complications and less chance of spread than in other forms of treatment; (5) there is no pain or discomfort attending the treatment; (6) advanced, serious cases of erysipelas, involving fairly large areas, with high temperature and general infection, may be treated successfully.

F. B. SHELDON, M.D.

The Treatment of Erysipelas by Roentgen Ray. J. Edward Harbinson and John D. Lawson. Calif. and West. Med., April, 1927, p. 485.

The effect of roentgen rays on unicellular organisms.—In this second series of experiments a number of unicellular organisms were exposed to radiation of lambda effective 1.47. The erythema dose is 380 *R* (70 K.V., 9 ma., 7.5 cm. distance, no filter). It required 767 E.D., 10 minutes, to kill *Trichophyton crateriforme;* 767 E.D., 10 minutes, to kill *Trichophyton umbilicatum;* 767 E.D., 10 minutes, to kill *Achorion Quinckeanum.* Fresh water amœba were treated 45 minutes with 3,450 E.D., equal to 1,312,000 *R.* A definite retardation of their movements could be observed. Increasing the time to 75 minutes (5,750 E.D. or 2,190,000 *R*) showed the same effect as before only in a higher degree. None of the amœba were killed.

E. A. POHLE, M.D.

X-rays of Unicellular Organisms (II). G. H. Kloevekorn and O. Gaertner. Strahlentherapie, 1927, XXIV, 548.

Radiological aspect of goiter.—This paper is one of a series of three comprising a symposium on the medical, surgical, and radiological aspects of goiter, read at the annual meeting of the Canadian Medical Association.

The results obtained from the radiotherapy of goiter will depend on the correctness of the diagnosis, and good judgment in the selection of cases for radium or X-ray therapy. The author classifies goiter into (1) physiological, (2) pathological non-toxic, and (3) pathological with hyperthyroidism. In the

verification of the clinical diagnosis the most important method is the estimation of the basal metabolic rate, which is an accurate indication of the presence or absence of hyperthyroidism. For the radiation treatment of ambulatory cases the X-ray is preferred, while the very toxic, bedridden cases are best treated by radium.

The author's X-ray technic is: 100 K.V. (sphere gap), 5 ma., 10 inches skin target distance, 3 mm. aluminum filter, 5 minutes to each side of the neck. This dosage is usually administered once a week for four treatments. After an interval of two weeks this routine is repeated, if the basal metabolic rate is still high. If the toxicity is found to be reduced, the series of four treatments is repeated, but with intervals of two weeks between treatments, instead of one week.

For radium treatment the neck is blocked out into five areas—two over each lobe of the thyroid, and one over the thymus. One hundred mg. hours is given to each area for each 10 per cent increase in toxicity. Gamma rays are used, and 2 cm. of felt is used to give distance. The series occupies five days. After three months, if the toxicity persists, the series is repeated. The dosage is regulated, as before, by the degree of toxicity.

The comparative advantages and disadvantages of surgery and radiation therapy are discussed. Surgery offers quick results in large colloid, adenomatous, and cystic goiters. On the other hand, radiation results in no fatality, no pain, no scar, and no interference with occupation. The disadvantages of radiation therapy, as claimed by the surgeon, are slowness, possible production of myxedema, injury to parathyroids, and adhesions. The disadvantages of surgery, as claimed by the radiologist, are fatalities, scars, added expense, tetany, myxedema, and possible hypertrophy of the remaining gland.

In summing up, the author considers that the treatment of goiter belongs primarily to the internist, who alone should be the judge as to the proper measures to be adopted. In co-operation with the surgeon and radiologist he should determine whether surgery, radiology, or purely medical measures, or a combination of two or more of them, should be the mode of treatment.

L. J. CARTER, M.D.

Goiter from a Radiologist's Viewpoint. W. H. McGuffin. Can. Med. Assn. Jour., October, 1926, p. 1182.

Roentgen rays of very long wave length.—The author describes a special tube with Lindemann window (glass of low atomic weight). The potential used varies from 6 to 10 K.V., producing roentgen rays of approximately 2 Ångstroms. The preliminary experience in what might be called ultra-superficial therapy of skin lesions is related and other possibilities of this radiation are discussed.

E. A. POHLE, M.D.

Principles and Future of the "Borderline Rays." G. Bucky. Strahlentherapie, 1927, XXIV, 524.

Examination for diverticula.—This is an excellent clinical article presenting the symptomatology, pathology, diagnosis, complications, and treatment of the various types of this condition. The author rather minimizes the value of the roentgen ray in the diagnosis of this condition, stating that in the acute cases opaque enemas should be given with a good deal of caution owing to the danger of the rupture of a diverticulum. In chronic cases diverticula may be outlined by an opaque meal or an enema and may retain the barium two or three days. However, diverticula may be completely filled with fecal material and then no barium will enter. He draws attention to the fact that films should be taken several days after the barium has escaped from the bowel so that the diverticula can be seen without being covered by the bowel shadow.

The relationship of diverticulitis to cancer of the colon is discussed. Ballin mentions that carcinoma of the colon should not be diagnosed as such without a definite microscopical biopsy of the tissue, in case there is existing

inflammation, as many of these cases will clear up following an enterostomy above the neoplasm. The statement is made that carcinoma frequently originates in diverticula. The author believes that this carcinoma has two characteristics: (1) The cancer often does not grow toward the lumen of the bowel and therefore gives no filling defect in the roentgenogram; (2) The symptoms from this type of cancer will not be partial obstruction, but the early symptoms will be slow perforation and abscess formation outside of the bowel, appearing retroperitoneally in the lumbar or inguinal regions.

HOWARD P. DOUB, M.D.

Diverticulitis of the Colon. Max Ballin. Am. Jour. Surg., February, 1927, p. 130.

Histology of effect of roentgen rays in carcinoma.—In this paper the authors relate in detail the history of a woman 75 years of age, suffering from carcinoma in the right zygomatic region, approximately $10 \times 3\frac{1}{2} \times 2\frac{1}{2}$ cm. in size. Biopsy revealed a typical basal cell carcinoma. Half of the tumor was treated with one full dose (15 H., 0.5 Zn., 45 min.), the other half with one-third of this dose on three successive days. Beginning two hours after the treatment, another biopsy was done, followed by others, making a total of fifteen during a period of one year. There were two recurrences which responded finally to repeated irradiation. Comparing their findings with observations published by Alberti and Politzer, on irradiated embryonic tissue, there seems to be fair agreement. The primary effect of radiation is a decrease in the number of mitoses, noticeable two hours after the first exposure, while, following an interval of quiescence, the new mitoses were atypical (secondary effect). A treatment in this interval, which is almost free of mitosis, had also an effect. The number of mitoses in a tumor does not seem, therefore, to have a bearing on its susceptibility to radiation. No difference could be noticed between the response of the growth to the full or fractional dose.

E. A. POHLE, M.D.

Regarding a More Exact Knowledge of the Effect of Roentgen Rays on Carcinoma. H. Hamperl and G. Schwarz. Strahlentherapie, 1927, XXIV, 607.

Gastric ulcer.—The patient, a man of 65 years, was referred for roentgen examination of the gastro-intestinal tract. The patient gave a history of gastric ulcer of two years' duration, with almost constant pain since three weeks before admission. After administration of barium sulphate and a screen examination, the patient was transferred to a table for plates. He suddenly complained that the pain was more severe, and examination disclosed typical physical findings of a perforation. The plate showed barium escaping from a perforation in the lower end of the stomach.

Immediate operation verified the roentgen findings. The perforation was closed, the patient making an excellent recovery and being discharged free of symptoms six weeks later.

H. J. ULLMANN, M.D.

Perforation of Gastric Ulcer during X-ray Examination. F. W. Lang. Lancet, Nov. 20, 1926, p. 1061.

Duplicate kidney pelvis and bifid ureter.—The author describes a case of duplicate kidney pelvis and bifid ureter, complicated by advanced hydronephrosis and megalo-ureter containing calculi.

In this case a large mass was palpated about the left kidney. A catheter up the left ureter was stopped a few centimeters from the bladder orifice. X-ray showed the calculus at the site of stoppage. At operation it was found to be a bifid left ureter, each branch terminating in a distinct pelvis. The lower common part of the ureter held tightly impacted calculi, which had prevented the passage of the ureteral catheter into either V-branch of the

double ureter, as well as the making of ureteropyelograms.

ROBERT A. ARENS, M.D.

Hydronephrotic Double Kidney with Bifid Megalo-ureters: Report of a Case. Edward W. White. Jour. Urol., April, 1927, p. 439.

Milliamperemeter control in therapy.—In order to prevent errors in dosage by wrong reading of milliamperemeters, the author suggests the use of two meters, one of which is shortened and may be placed in the circuit by a simple device controlled from the operator's stand. Frequent checks of the deflection of the permanently recording meter by this control instrument will increase the safety.

E. A. POHLE, M.D.

Errors in Dosage during Roentgen-ray Treatments Caused by Wrong Reading of the Milliamperemeter, and Their Prevention. Ernst Fritsch. Strahlentherapie, 1927, XXIV, 719.

Mechanism of physical signs of the chest.—In discussing the mechanism of physical signs of the chest and in evaluating their diagnostic significance and prognosis, the author endeavors to show that roentgenology could be used to a decided advantage. Use of roentgenology in pulmonary cavities, pneumothorax, certain râles, functional rubs and compensatory emphysema aided in elucidating the mechanism of many of these signs and somewhat revised their diagnostic interpretation.

Pulmonary cavities are not diagnosed physically, in about half the number of cases, by classical signs. Such mute cavities can be seen by the roentgenoscope and, with such findings as modified breath sounds and moist inspiratory râles over these areas, cavities are diagnosed. It was also found that subcrepitant crackling râles, heard over an area on deep inspiration, are due to functional atelectasis. These areas light up on the fluoroscopic screen. Subcrepitant râles which are elicited only after cough are due to edema, or infiltration of the alveolar walls: these do not light up. In cases of pneumothorax a moist râle heard over the sternum and thoracic vertebræ is due to a pendulum-like movement of a labile mediastinum. In compensatory emphysema the marked distention and contraction of the dilated lung causes the breath sounds to become exaggerated.

ROBERT A. ARENS, M.D.

Roentgenology as an Investigational Field in the Mechanism and Diagnostic Significance of Physical Signs of the Chest. Raphael A. Bendove. Am. Jour. Med. Sci., March, 1927, p. 322.